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Instruction Book

P O L Y S K O P

Type SWOB BN4244

ROHDE & SCHWARZ
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Note: Always quote the Type and Order Number (BN) in addition to the Serial Number (FNr.) of the set when asking for technical information and, in particular, when ordering repair parts.

Edition R 6194/259

098; 958; 50 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

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1. What is the POLYSKOP

1.1 Short General Description (see figure 1)

The POLYSKOP is a practical test set which combines in a single instrument the individual pieces of test equipment needed for exact voltage-frequency measurements. The frequency range extends from 500 kc to 400 mc. The pictorial diagram of figure 1 shows a measurement being made with and without the POLYSKOP. From this diagram you can readily see the conveniences that the POLYSKOP will offer you. The POLYSKOP combines the following pieces of equipment:

A S i g n a l G e n e r a t o r with the frequency range extending from 500 kc to 400 mc whose EMF must be held constant throughout the entire frequency range ...

the POLYSKOP contains this signal generator with the great advantage that the tedious work required to keep the EMF at a constant value is done by an effective automatic-control circuit.

A C a l i b r a t e d A t t e n u a t o r , with whose help you can set the desired signal generator output voltage .....

the POLYSKOP contains this attenuator possessing 10-db steps between -10 db and -60 db. 3 db is provided by pressing a button.

A V a c u u m - t u b e V o l t m e t e r which measures the input voltage to the test object throughout all frequency variations. The test object input voltage is measured by a built-in diode in the r-f output socket of the signal generator .....

is also contained by the POLYSKOP which makes it possible to avoid many sources of error, which are caused by mismatch.

A V a c u u m - t u b e V o l t m e t e r with a terminated socket, or an r-f probe which indicates the voltage as a function of frequency at the output of the test object .....

also such a highly accurate terminating resistance with a built-in diode is contained in the POLYSKOP. The measuring sensitivity lies far above that which a normal broad-band VTVM offers.

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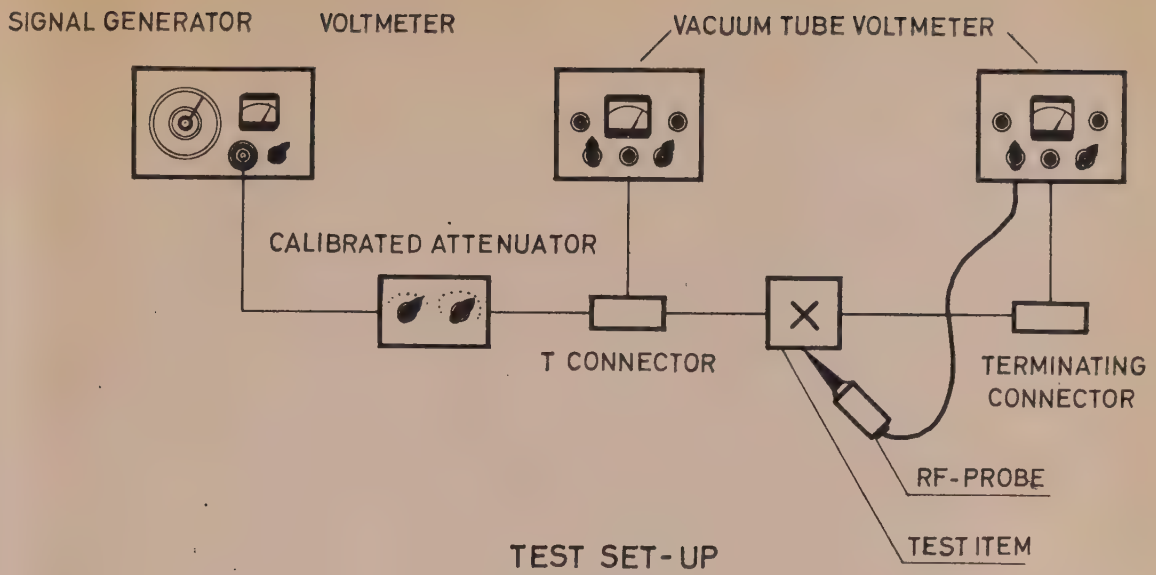


TEST SET-UP

consists of

several signal generators for the entire range from 0,5 to 400 mc
calibrated attenuator
vacuum-tube voltmeter with T connector
vacuum-tube voltmeter terminating connector or
diode probe

are all replaced with
one single instrument

POLYSKOP

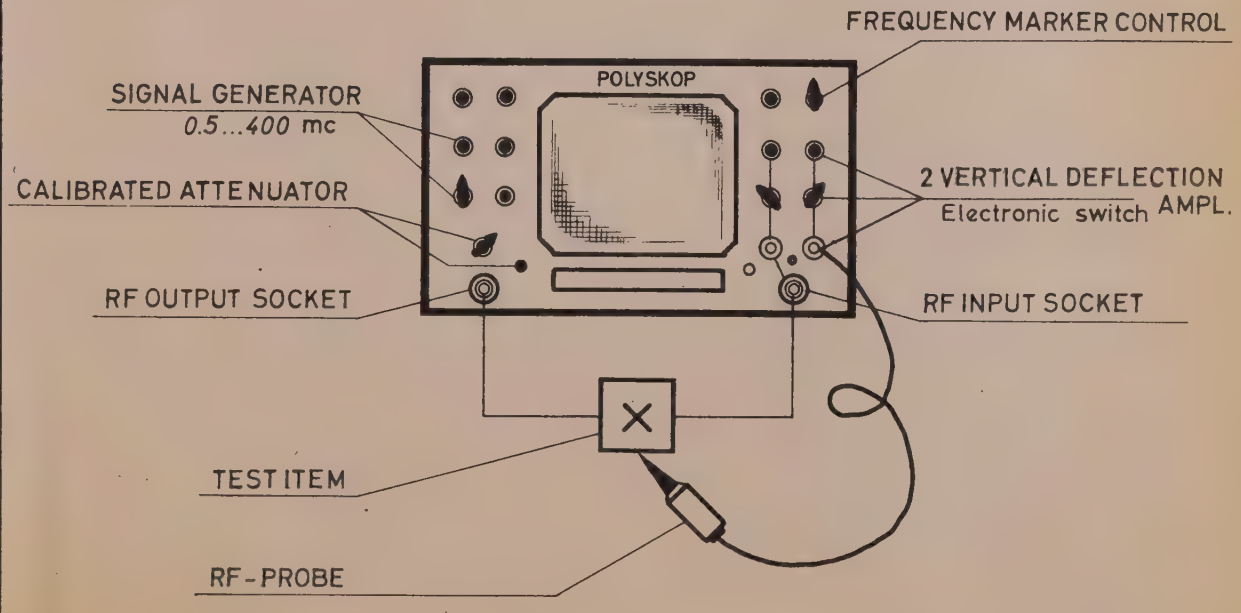
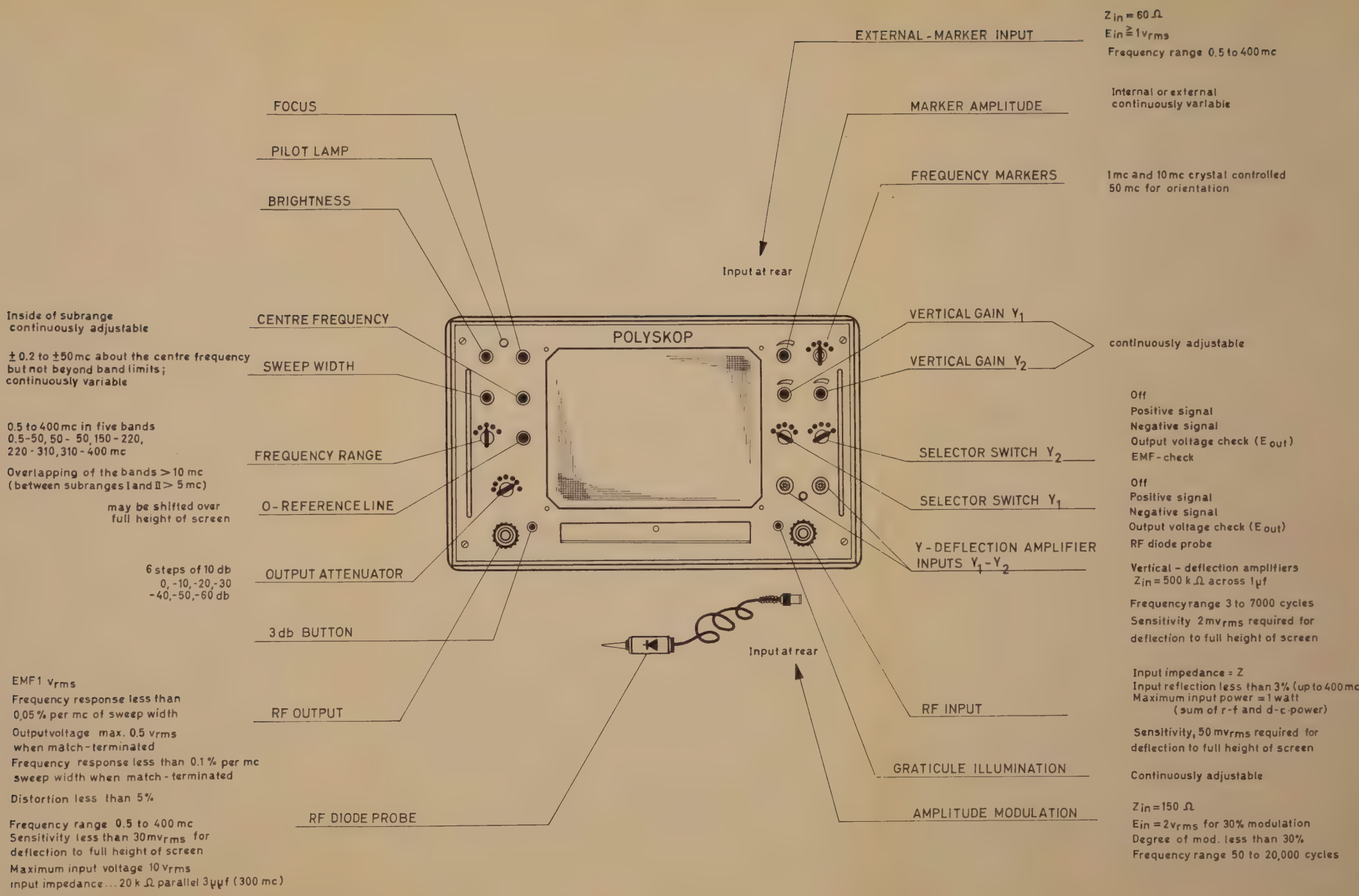


Fig. 1

42; 856; 100x100 S; ROHDE & SCHWARZ, MÜNCHEN


EXTERNAL - MARKER INPUT
$Z_{in} = 60\ \Omega$
$E_{in} \geq 1\ v_{rms}$
Frequency range 0.5 to 400 mc
FOCUS
MARKER AMPLITUDE
Internal or external continuously variable
PILOT LAMP
FREQUENCY MARKERS
1 mc and 10 mc crystal controlled 50 mc for orientation
BRIGHTNESS
Input at rear
Inside of subrange continuously adjustable
CENTRE FREQUENCY
VERTICAL GAIN Y_1
POLYSKOP
continuously adjustable
± 0.2 to ±50 mc about the centre frequency but not beyond band limits; continuously variable
SWEEP WIDTH
VERTICAL GAIN Y_2
Off
Positive signal
Negative signal
Output voltage check (E_{out})
EMF - check
0.5 to 400 mc in five bands 0.5-50, 50 - 50, 150 - 220, 220 - 310, 310 - 400 mc
FREQUENCY RANGE
SELECTOR SWITCH Y_2
Overlapping of the bands > 10 mc (between subranges I and II > 5 mc)
Off
Positive signal
Negative signal
Output voltage check (E_{out})
RF diode probe
may be shifted over full height of screen
0 - REFERENCE LINE
SELECTOR SWITCH Y_1
Y - DEFLECTION AMPLIFIER INPUTS $Y_1 - Y_2$
6 steps of 10 db 0, -10, -20, -30 -40, -50, -60 db
OUTPUT ATTENUATOR
Vertical - deflection amplifiers $Z_{in} = 500\ k\Omega$ across $1\mu f$
Frequency range 3 to 7000 cycles
Sensitivity 2 mv_{rms} required for deflection to full height of screen
3 db BUTTON
Input at rear
Input impedance = Z
Input reflection less than 3% (up to 400 mc)
Maximum input power = 1 watt (sum of r-f and d-c power)
EMF 1 v_{rms}
Frequency response less than 0,05 % per mc of sweep width
RF INPUT
Sensitivity, 50 mv_{rms} required for deflection to full height of screen
Output voltage max. 0.5 v_{rms} when match - terminated
Frequency response less than 0.1 % per mc sweep width when match - terminated
GRATICULE ILLUMINATION
Continuously adjustable
Distortion less than 5%
RF DIODE PROBE
AMPLITUDE MODULATION
$Z_{in} = 150\ \Omega$
$E_{in} = 2\ v_{rms}$ for 30% modulation
Degree of mod. less than 30%
Frequency range 50 to 20,000 cycles
Frequency range 0.5 to 400 mc
Sensitivity less than 30 mv_{rms} for deflection to full height of screen
Maximum input voltage 10 v_{rms}
input impedance ... 20 k Ω parallel 3 μμf (300 mc)

Technical data of the POLYSKOP

Fig. 2

Finally, the POLYSKOP contains various F r e q u e n c y M a r k e r s , which are useful for many other purposes besides the exact measurement of frequency.

Everything that you need for the accomplishment of exact measurements in the high- and video-frequency ranges is built into the POLYSKOP. In addition, the POLYSKOP automatically displays t w o v a r i a b l e s at the same time on a large picture tube. With the POLYSKOP, you are able to do many measurement jobs in a fraction of the time it would take if the job were done by static means, and the measurements are just as accurate as those made on a test setup put together with considerable effort.

Sections 3. and 4. of this instruction book are devoted to the question of how you can recognize measuring errors and avoid them and for what measurements the POLYSKOP is not suited. Finally, we recommend that you read over the fundamentals of sweep-frequency measurements found in section 9. at the back of the instruction book where everything worth knowing is consolidated. This will make it easy for you to apply the POLYSKOP successfully to your problem.

1.2 Technical Data of the POLYSKOP (see figure 2)

In figure 2 you will find the technical data of the POLYSKOP as well as the locations of the outer connections and control knobs. Sections 5. and 6. contain further information over the technical characteristics and the recommended accessories.

2. Operating Instructions for the POLYSKOP

2.1 Setting into Operation

The POLYSKOP Type SWOB leaves our factory adjusted for operation from 220 v a-c. To adjust it for 115 v, 125 v or 235 v, remove the chassis from its cabinet and insert the proper fuse into the clips marked on the fuse panel to correspond with the local a-c supply voltage. The fuse panel is located above the power transformer. The fuse rating is 2 amperes for 115 v and 125 v; for 220 v and 235 v, it is 1 ampere.

The power cord LK 333 supplied with the set is connected to the rear of the POLYSKOP. The positions of the control knobs and connections can be seen from figure 3.

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The power and brightness switches are combined and controlled by knob (2). To switch the POLYSKOP on, turn this knob slightly clockwise. The pilot lamp (2a) is the voltage indicator. Allow one minute for warming up and turn the BRIGHTNESS control clockwise until the horizontal 0-reference line appears on the screen. Adjust the FOCUS control (1) for minimum thickness of the trace. Until the set is completely warmed up, it is necessary to readjust the FOCUS control several times. Vertical positioning of the 0-reference line is possible with the 0-LINE control (6). Normally, this line is brought to coincidence with the engraved zero line of the graticule. Should the 0-reference line be slanted, please read sections 7. and 8., "Maintenance and Repair".

2.2 Functional Check, Short-circuit Measurement

We recommend that the POLYSKOP be checked for proper operation by means of a short-circuit measurement before putting the set into use.

2.2.1 Checking the EMF

The EMF of the built-in signal generator is held constant with the aid of an automatic control circuit. It is possible to make the following check to convince yourself that the EMF exhibits no frequency response:

(1) Set the OUTPUT ATTENUATOR (8) to at least -10 db.
(2) Turn the Y_1 selector switch (15) to the position "OFF".
(3) Place the Y_2 selector switch (16) in the position "EMF".
(4) Advance the Y_2 gain control (17) until the EMF curve is displayed.

With maximum sweep width (SWEEP WIDTH control (4) turned completely clockwise) and the CENTRE FREQUENCY control (3) placed in its middle position, the EMF curve should not show any noticeable frequency response in all of the five ranges of the POLYSKOP. In figure 4, you see two horizontal lines in the frequency range between 50 and 400 mc. During the period of the return trace, the r-f oscillators are blanked so that the 0-reference line is visible.

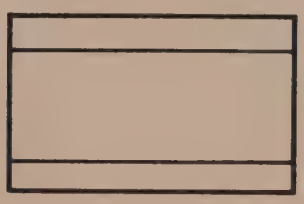

Fig. 4

1·058·50×100 S· ROHDE & SCHWARZ MÜNCHEN

In the frequency range 0.5 to 50 mc, the display appears somewhat different (see figure 5). The sharp break at the left-hand side is caused by the lower limit frequency at 0.5 mc; the fall-off at the right-hand side is caused by the upper limit frequency at approx. 55 mc.

Fig.5

By manipulating the CENTRE FREQUENCY (3) and the SWEEP WIDTH (4) controls you can set in any desired frequency sub-range within the specified frequency limits. Should a blanking of the oscillogram appear at the left-hand side, this is an indication that the frequency sweep has exceeded the lower frequency limit of the selected range. This indication protects you against a measuring error caused by a maladjusted frequency sweep. For particulars on the necessity of blanking, please read section 5. in the POLYSKOP Circuit Description.

2.2.2 Measurement of the Output Voltage (E_{out})

First terminate the POLYSKOP r-f output with a good resistance such as our UHF Standard Resistors Type RMD. Next switch the OUTPUT ATTENUATOR to 0 db and then place either of the two selector switches (15) or (16) in the position "E_{out}". No substantial frequency response should be recognizable even though an absolute agreement between the E_{out}-indication and the EMF cannot be expected, since certain sources of error in the attenuators and cable connections are unavoidable. For this reason you will find discrepancies in the tolerance given for the "Flatness of Output Level" in the Specifications. If you measure the POLYSKOP output voltage with the OUTPUT ATTENUATOR placed at -20 db, you will recognise a certain amount of fluctuation in the indication, especially in the range 0.5 to 50 mc. This is caused by the small distortion of up to 5% present in the POLYSKOP signal generator output. Diode detector arrangements, which are also used in the POLYSKOP for indications, respond strongly to distortion in the measured signal. For particulars, please read paragraphs 4.3 and 9.6.

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2.2.3 Measurement of the Short-circuit Frequency Response

You have checked the proper functioning of the POLYSKOP from the standpoint of the signal generator through the measurements carried out under paragraphs 2.2.1 and 2.2.2. Only the proper functioning of the RF INPUT SOCKET containing the diode detector for the response indications remains to be checked. The following procedure should be followed in making the check:

Connect the RF OUTPUT (8) to the RF INPUT (12) with a good cable (such a cable is supplied with the POLYSKOP). Place the selector switch Y_1 (15) in the position "RF" and the OUTPUT ATTENUATOR in the position "0 DB". The deviation of the frequency response curve should not be more than 5%. With reduced signal-generator voltage (for example -20 db), the deviation may be larger for the reasons given in detailed form under paragraph 2.2.2.

2.2.4 Display of Two Voltage Variables

If both selector switches (15) and (16) are switched from the "OFF" position, the voltage variables applied to the Y_1 and Y_2 amplifiers are written alternately at one half the a-c supply frequency. A built-in electronic switch makes the switch-overs, displaying both voltage variables simultaneously on the picture screen. The electronic switch is shut off if one of the selector switches is placed in the position "OFF", the writing frequency becomes equal to the a-c supply frequency (48 - 62 cps).

2.3 Adjusting any given Sweep Width

For example, a frequency that sweeps from 210 mc to 216 mc is desired. To adjust this or any desired frequency, the following procedure is recommended:

(1) Switch the frequency range switch to the 150-220 mc band and select the 50-mc frequency markers.

(2) Turn the SWEEP WIDTH control completely clockwise. Notice two markers in the display, the left one at 150 mc and the right one at 200 mc.

(3) Bring the 200-mc marker to the left-hand side of the display by decreasing the sweep width with the SWEEP WIDTH control and manipulating the CENTRE FREQUENCY control.

(4) Switch on the 10-mc marker spectrum and locate the marker for 200 mc, 210 mc and 220 mc, respectively.

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(5) Bring the 210-mc marker to the left-hand and the 220-mc marker to the right-hand side of the display by further manipulation of the SWEEP WIDTH and CENTRE FREQUENCY controls.

(6) Switch on the 1-mc marker spectrum.

With repeated control manipulations, the frequency sweep between 210 mc and 216 mc may be displayed across the picture-tube screen.

2.4 Applying External Markers

A signal generator which delivers approx. 1 v_{rms} across 60 Ω at the desired marker frequency is necessary for applying external markers to the POLYSKOP. The signal generator output voltage is connected at the rear of the set with a R&S Dezifix connection. The frequency markers are adjusted to the desired display amplitude with control (20). With the selector switch (19) placed in the position "EXT", only the external applied markers are visible. In the positions 1, 10 or 50 mc, the external markers appear with the internal markers.

2.5 Modulation Input

It is possible to amplitude-modulate the POLYSKOP r-f output voltage. The necessary signal voltage input connection is located at the rear of the set. The POLYSKOP may be amplitude-modulated up to an upper frequency of 20 kc. However it must be noted that when making a short-circuit check or other measurements using the POLYSKOP vertical-deflection amplifier, the frequencies over 7 kc do not appear at the full display height since this amplifier has an amplitude response only up to 7 kc.

2.6 Measuring with the RF Diode Probe

The two r-f diode probes supplied with the POLYSKOP are characterized by a small input capacity and a high sensitivity. R-f voltages of a few millivolts can be displayed at full height on the screen of the POLYSKOP. However you must be certain that a good earth connection is made to the probe enclosure as close as possible to the point of measuring. The two replaceable probe tips are not meant to be soldered to the measuring point since the plastic disk in the diode probe would be damaged. In order to solder the diode probe into the circuit under test, unscrew the probe tip and fasten a soldering lug to the diode probe with a suitable screw. The diode probes are safe for d-c voltages up to 500 v. They contain a voltage-doubler circuit and deliver a positive polarized output voltage.

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The r-f probe marked by a red ring has one side of the rectifier circuit connected to the probe enclosure through a capacitance. This probe is less sensitive with reference to hum pickup. However there are cases, depending upon the test setup, where the r-f earth relationships are not defined. This is recognized by the fact that the indications change when the r-f probe is touched or moved about. These instable indications cannot be tolerated under any circumstances since they indicate a measuring error. In these cases, try using the r-f probe not marked with a red ring. This probe has its rectifier circuit connected directly to its enclosure which is in turn connected to the cable shield. Further information as to how you can recognize measuring errors and avoid them can be found specially under section 4.

2.7 Investigations on Test Objects with Built-in Rectifiers

In most cases, receivers and intermediate frequency amplifiers already contain rectifiers for the demodulation of the r-f voltages. It is possible to feed a demodulated voltage directly from the test object to the input of one of the vertical-deflection amplifiers. Loading effects on a demodulator circuit remain quite small if an isolating resistance of 100 kΩ is placed between the measuring point and the input of the vertical-deflection amplifier. It is also recommended that a shielded cable be used for the connection between the test object and amplifier input. If the test object has an amplifier stage following its demodulator, the POLYSKOP may be connected to this amplifier only if its frequency response extends down to at least 1 cps. This condition is practically never met so that in general the POLYSKOP should be connected directly to the demodulating circuit of the test object if errors are to be avoided. Depending upon the polarity of the voltage taken from the demodulator circuit, the selector switch (15) or (16) is placed in the position "POS" or "NEG". The vertical-deflection amplifier inputs (13) and (14) of the POLYSKOP are safe for d-c voltages up to 500 v.

2.8 Response Amplitude Measurements

The exact response voltage amplitude cannot be read from any picture-tube graticule.

Diode rectifier arrangements such as those used in the r-f input socket and the test probes are from their nature non-linear elements. At low r-f voltage levels, the relationship between the r-f voltage

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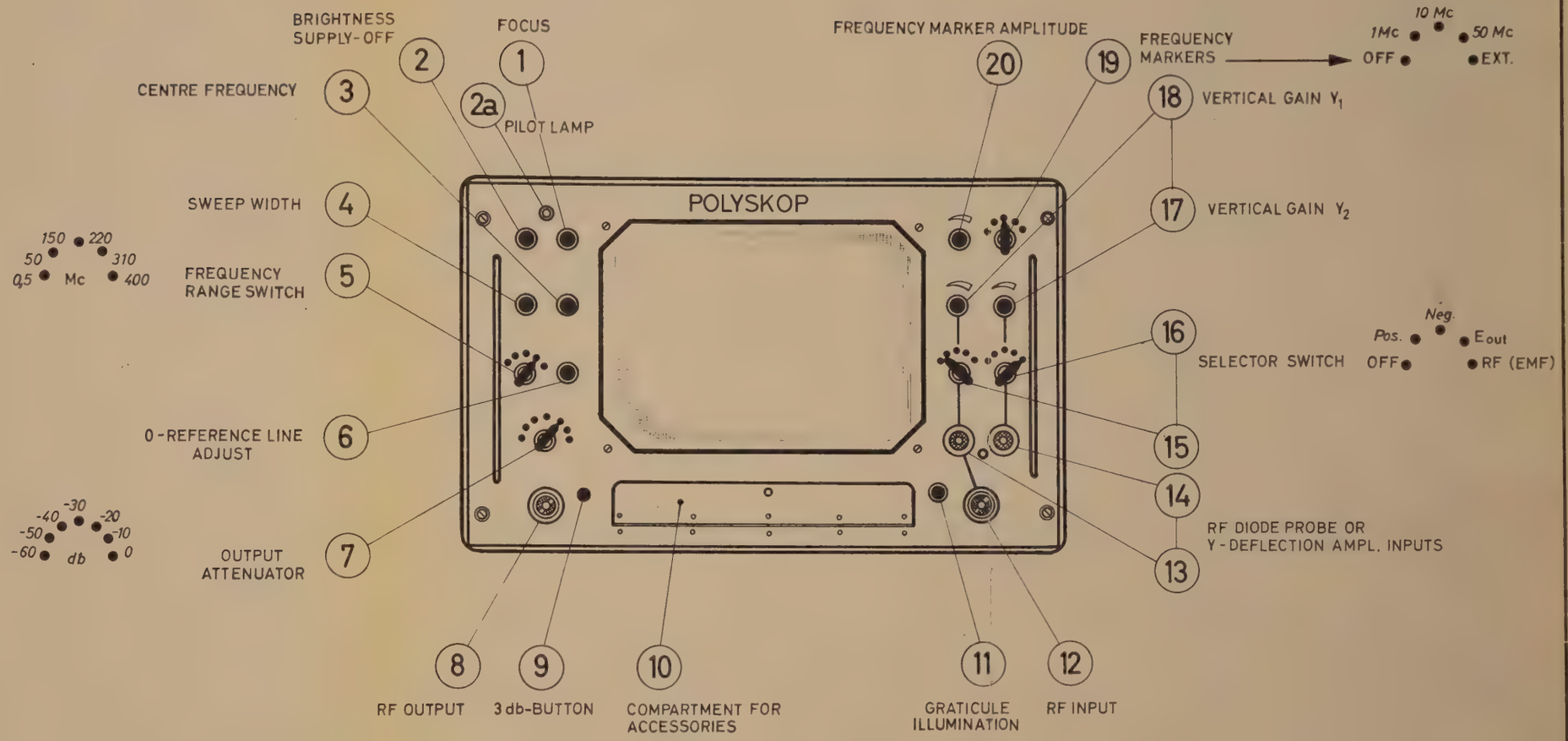

POLYSKOP

Front Panel Controls

Fig. 3

and the rectified diode current is particularly non-linear. It was therefore not possible to provide the plexiglass picture-tube protector with a db-calibrated scale. For this reason, the amplitude measurements must be made indirectly by the comparison of voltage level changes of the signal generator output voltage. This method ensures that the non-linearity of the diode used for rectification, even if contained in the test object, does not enter into the measuring accuracy. A further advantage of the indirect method of measurement lies in the fact that overdriving the test object is immediately recognizable.

The two built-in calibrated signal generator output attenuators of the POLYSKOP permit a definite voltage level drop of 3, 10, 13, 20, 23 db, etc. up to a maximum of 63 db. For example, it is possible to press the button marked "3 DB" to determine the voltage level of the display that corresponds to 3 db, provided the gain of the vertical-deflection amplifier is held constant. Voltage level drops of 1 db or 2 db can be made by linear interpolation with an accuracy within 0.2 db. A practical aid for marking a desired voltage level is by placing the vertical-deflection amplifier selector switch (16) in the position "EMF" and using the trace of the signal generator emf as a reference line. This helps considerably when level drops of more than 10 db are to be measured. The interpolation error is about 1 db for the intermediate values which cannot be adjusted such as 4, 5, 6, 7, 8, 9 db, 14, 15, 16 db, etc. If a higher measuring accuracy is desired, it is possible to use a 1-db step adjustable attenuation box such as our Standard Attenuator Type DPR connected between the POLYSKOP and the test object.

3. Examples of Application

3.1 Measurement of a Single Resonant Circuit

Single resonant circuits, which are used as coupling devices between two amplifier stages, are best investigated with test setup shown in figure 6.

3.1.1 Connecting the Signal Generator to the Test Object

For this purpose, you may use a cable that is not too long with an open end that can be soldered to the grid of the first amplifier stage. With such makeshift commections, you must take care to ensure that a

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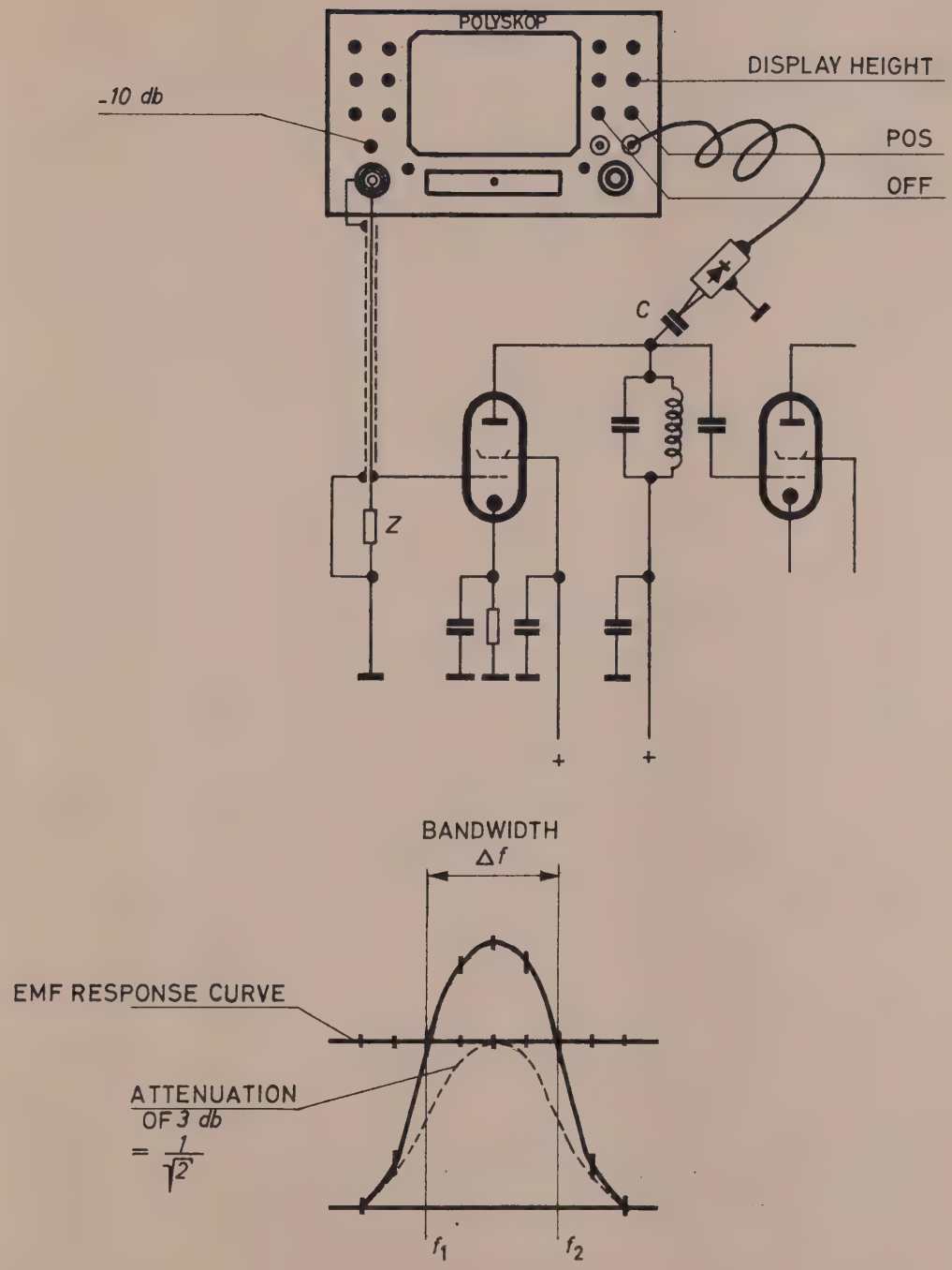

MEASUREMENT OF SINGLE RESONANT CIRCUITS WITH THE

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Fig. 6

856; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

good impedance match is made. To make certain of this, use one of the beams to trace the output voltage E_{out} as a function of frequency while the other beam is used for the test results.

The fluctuation of E_{out} must not vary more than 20% in the frequency range used for measuring. If these fluctuations are greater than 20%, it is necessary to compensate the input impedance at the grid of the first amplifier stage by adding either capacitance or inductance before beginning any measurements. Even if you have terminated the cable with its characteristic impedance, you cannot expect an exact impedance match because of the valve input impedance with its associated capacitance. In most cases, compensation is not necessary for bandwidths under 2 mc when the connecting cable to the test object is shorter than 1 metre.

3.1.2 Measuring the Resonance Frequency

In order to measure a resonance frequency, it is sufficient in most cases to fasten the r-f diode probe to the chassis at a short distance from the resonant circuit under investigation. It is also possible to couple to the anode of the amplifier valve using a small capacitor with 0.5 to 1 µµf. The detuning and damping of the resonant circuit remain so small that you can accurately measure the resonant frequency and bandwidth of the tuned circuit. Only with low gain amplifier stages and low Q resonant circuits is it necessary to make a direct connection with the r-f diode probe. The resonant frequency of a tuned circuit is determined with the help of the frequency markers.

3.1.3 Measuring the Q of a Tuned Circuit (Bandwidth)

To measure the Q of a resonant circuit, use the following procedure:

(1) Place the selector switch (16) of the vertical-deflection amplifier in the position "EMF". The trace obtained can now be used as a reference line.

(2) Press the "3 DB" button so that the height of the displayed resonance curve is reduced by exactly 3 db.

(3) Place the reference line at the top of the resonance curve with the aid of the vertical gain control "Y_2".

(4) Now release the "3 DB" button.

With the aid of the reference line marking the 3-db level and the frequency markers, determine the lower and upper frequency limits, f_1 and f_2, which establish the bandwidth.

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The Q of the resonant circuit is calculated from the relationship

$$Q = \frac{f_o}{\Delta f}$$

where Δf is the bandwidth (f_2-f_1) and f_o is the resonant frequency.

3.1.4 Possibility of Measuring Errors

With tuned circuit bandwidths of less than 50 kc, automatic sweeping at the a-c power frequency may be too rapid, and thus cause measuring errors to occur with respect to bandwidth measurements as well as in the determination of the resonant frequency. For further information, please read section 4. and paragraph 9.5.

You must be careful that the test object is not overdriven. When feeding the POLYSKOP output voltage directly to the grid of an amplifier valve, the calibrated output attenuator must be switched to at least -10 db.

3.2 Measurements on Coupled Resonant Circuits (coefficient of coupling and bandwidth of band-pass filters)

For the measurement and alignment of band-pass filters, the possibility of the simultaneous display of two quantities proves itself to be especially useful.

3.2.1 Test Setup

The recommended test setup is depicted in the sketch of figure 7. The grid of the first amplifier valve is connected to the POLYSKOP with a cable that is as short as possible. However, the same considerations with regard to impedance matching must be taken into account as was brought out in paragraph 3.1 over the measurement of single resonant circuits.

3.2.2 Measuring the Bandwidth

By lowering the output voltage of the POLYSKOP by 3 db as was done in the case of single resonant circuit measurements, the bandwidth of band-pass filters can be measured.

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3.2.3 Adjusting the Coefficient of Coupling of a Band-pass Filter

To make this measurement, one r-f diode probe is connected to the band-pass filter input in addition to one connected to the output.

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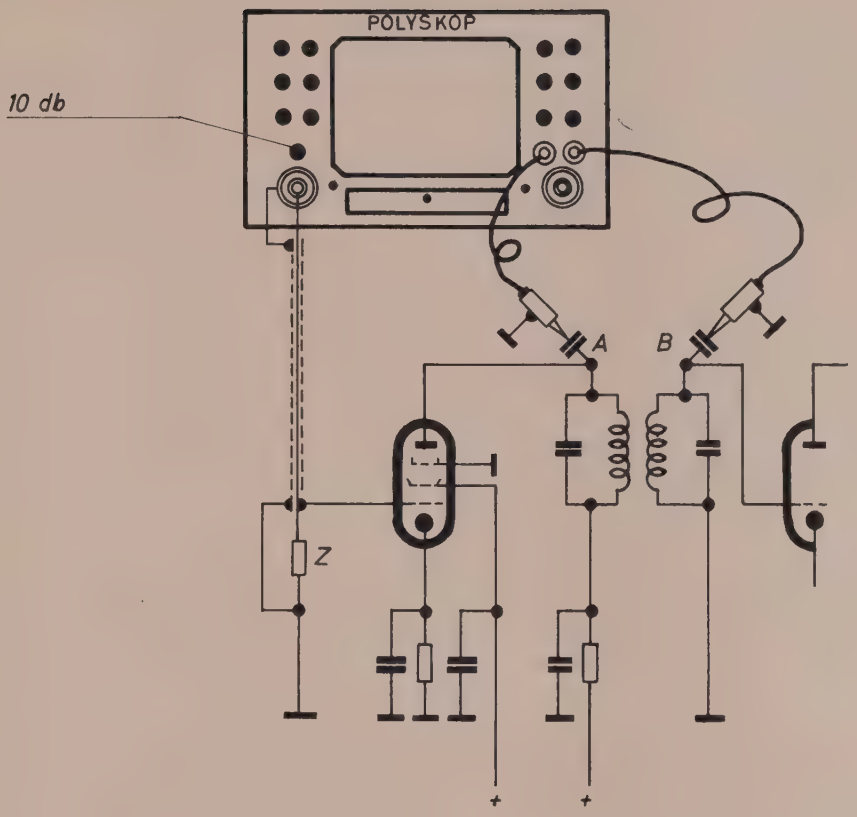

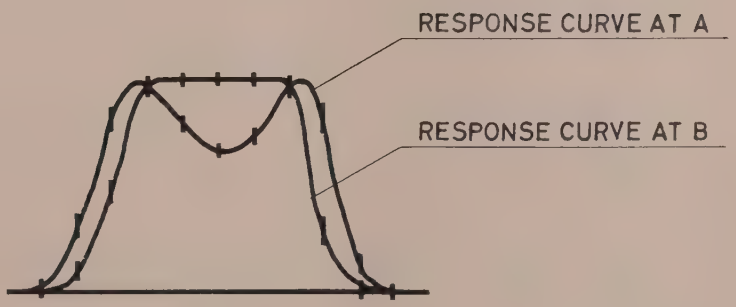

MEASUREMENTS ON BAND FILTERS WITH THE

POLYSKOP

Fig. 7

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Both connections are made through small coupling capacitors. The simultaneous display of the two resonance curves is presented on the screen of the picture tube. At critical coupling, the filter input response curve has a saddle depth that is equal to one-half of the saddle maxima at the limit frequencies. The pass-band centre frequency lies at the saddle minimum. In addition, the two saddle maxima should both have the same height if no stray coupling is present inside the amplifier stage.

3.2.4 Possibility of Measuring Error

Band-pass filters whose amplitude response rises from 10% to 100% within a frequency change of less than 20 kc cannot be measured exactly with the POLYSKOP. For particulars, please read section 4. and paragraph 9.5.

Also you should take care that the test object is not overdriven with an excessive output voltage from the POLYSKOP. An output attenuator setting of at least -10 db is recommended.

3.2.5 Measuring and Aligning Multistage IF Amplifiers

Multistage amplifiers can be aligned and measured with the POLYSKOP in the same manner as already mentioned. However, the possibility of measuring error increases as the number of i-f stages are increased because of the steepness of the amplitude response curve (see section 4. and paragraph 9.5).

3.3 Limiters and Discriminators

3.3.1 Limiters

By coupling one of the r-f diode probes with a small capacitor of 0.5 to 1 µµf to the anode circuit of a limiter, the output voltage response can be displayed. The range of the limiter action can be recognized by viewing the height of the response curve as the output voltage of the POLYSKOP is varied with the aid of the calibrated attenuator.

The usual limiter draws grid current which builds a grid bias voltage. This bias voltage can be coupled over a resistance of more than 100 kΩ to the available vertical-deflection amplifier so that both the output response as well as the grid voltage may be viewed simultaneously. The simultaneous display of these two voltage variables provides an especially clear picture of the limiter action.

958; 50 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

3.3.2 Discriminators

Detector arrangements are already contained in discriminators so that a discriminator output voltage can be directly coupled through an isolating resistor (over 100 kΩ) to the input of the POLYSKOP. Since the discriminator response curve lies symmetrically about a reference axis, the POLYSKOP 0-reference line is best placed in the centre of the display.

Of special value is the viewing of the response curve of the i-f amplifier connected ahead of the first limiter stage simultaneously with the discriminator response curve. Here you can see exactly whether the discriminator is correctly adjusted to the centre frequency of the pass band. By changing the output voltage of the POLYSKOP, you can check to see if the discriminator response curve remains unchanged throughout the required input level range. With this measurement, the proper functioning of all the limiter stages is also included.

3.3.3 Possibility of Measuring Error

The signal generator output voltage of the POLYSKOP is cut off during the oscillograph return trace. Because of the high amplification of an i-f amplifier with limiter and discriminator, the absence of an input voltage while the signal generator is cut off allows a high noise level to be applied to the discriminator. This is the cause of fluttering in the discriminator display curve. However, this fluttering can cause no distortion of the measured results.

Narrow-band i-f amplifiers having a pass band of less than 100 kc are subject to measuring errors caused from the automatic sweep frequency being too high (a-c supply frequency). Please refer to paragraph 9.5 for a detailed explanation.

If measurements are made on amplifier stages whose average current varies with the amount of input drive, the amplitude response may be distorted with a slope across the top of the curve. This is especially true of limiter amplifier stages. In general, the filtering and by-passing capacitors of the anode, screen-grid, and cathode circuits are so dimensioned that they present a sufficient short-circuit in the frequency range of the set. Since the sweep of the POLYSKOP occurs at the a-c power frequency, the filtering and by-passing is not sufficient in many cases to prevent variations in the operating voltages. The

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amplification of each stage then varies at the a-c power frequency making it impossible to avoid measuring errors.

In general, the following principles should be observed:

Amplifier stages, which do not operate class A (the anode current is a function of grid drive) must have filter or by-pass circuits with time constants greater than 10^{-1} or sufficiently large compared with the a-c power frequency, in the other case the filtering is sufficiently small so that the amplifier gain does not noticeably change during the sweep time. If the time constants do not meet this requirement, parallel capacitors must be added before making any measurements.

Naturally such steps are unnecessary for measurements on test objects which have anode current conditions that are independent of grid drive (class A). It is only possible to make measuring errors by overdriving an amplifier stage which upsets its pure class A operation.

3.4 Filter Alignment

Any passive element such as a low-pass, high-pass, or band-pass filter may be measured and aligned with the POLYSKOP. In addition to viewing the output response, you can view the degree of filter mismatch to a cable of known characteristic impedance Z_o by observing the height of the E_{out} wave pattern.

3.4.1 Connecting up the Test Object

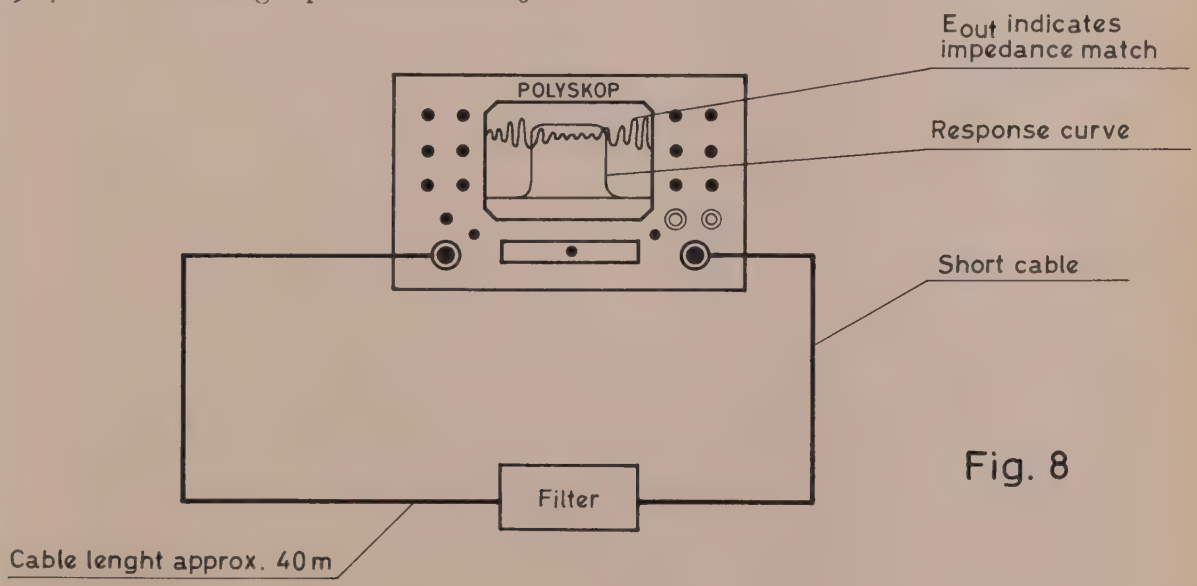

Fig. 8

The test object is connected to the POLYSKOP r-f input and r-f output as shown in the above diagram (figure 8). In order to view the wave

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pattern of E_{out} caused by mismatching, you must connect to the input of the test object a high quality cable that is at least 30 metres in length. A cable for this purpose can be delivered upon request for use with the POLYSKOP. Cables are available with various characteristic impedances. For more detailed information, please refer to the compilation of data and accessories under paragraph 6.6.

3.4.2 Measurements

By observing the test objects's response characteristic as well as its impedance match response, compensation problems can be solved in a very short time. Please refer to paragraph 3.12.6.

3.4.3 Interpretation of the Measured Results

Exact information over the measurement of input standing-wave ratios along with the obtainable measuring accuracies is given in paragraph 3.12, "Cable Measurements".

3.4.4 Filter Alignment Against a Standard

The double display possibility of the POLYSKOP is especially suitable for aligning test objects against a calibrated standard for use in mass production. The calibrated standard and the test object are both connected to the RF OUTPUT of the POLYSKOP by means of a 20-Ω T-connector. If a high quality long cable is used for the connection between the POLYSKOP and the T-connector, the test object's input impedance can be compensated with a reasonably high accuracy. The alignment of the test object is accomplished when the two displayed response curves sufficiently cover one another. By switching one of the two vertical-deflection amplifiers to the position "E_{out}", the input impedance match response curve of the test object can be displayed and measured.

3.4.5 Possibilities of Measuring Error

Extremely steep filter response curves cannot be exactly resolved with the POLYSKOP. Only the steepness of the response curve is important and not the bandwidth. For example, a low-pass filter with an extremely sharp cut-off at 10 mc cannot be measured with a frequency sweep of 10 mc. However, it is possible under certain circumstances to measure the cut-off region separately when it is not sharper than 20 kc for an amplitude drop from 100% to 10%. This measurement is made by decreasing the sweep width. Please refer to section 4. and paragraph 9.5.

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3.5 Measuring the Gain of an Amplifier Stage

To measure the gain of an amplifier stage, the following procedure is recommended:

(1) Connect the RF OUTPUT of the POLYSKOP to the input of the amplifier under test.

(2) Connect one of the r-f diode probes to the anode of the amplifier valve.

(3) Turn the vertical-deflection amplifier gain to maximum with control "Y_1" or "Y_2".

(4) With the aid of the OUTPUT ATTENUATOR control, increase the r-f output voltage attenuation until the response curve lies at the top of the display screen.

(5) Now connect the r-f probe to the amplifier input and decrease the r-f output voltage with the OUTPUT ATTENUATOR control until the response curve lies at the same place as under step 4.

The difference in the db-readings of the OUTPUT ATTENUATOR control is the db gain of the amplifier stage under test.

Since the POLYSKOP attenuation is only available in 10-db and 3-db steps, it is not possible to read the in-between values with a high degree of accuracy. However, it is possible in most cases to judge whether an amplifier stage is fundamentally functioning properly or not.

3.6 Video- and Distributed Amplifiers

For measurements on video-amplifiers, the lowest frequency range of 0.5 to 50 mc is especially suitable because of the large adjustable sweep width. Not only can you measure the frequency response range for which the amplifier is designed, but also the higher frequencies where resonant peaks may occur. In general, these resonant peaks can be attributed to unsuitable coupling capacitors or bad filtering which give rise to unexplainable overshoots when observing transients.

Of special importance when making measurements on distributed amplifiers is the fact that the r-f output voltage of the POLYSKOP remains at the same value as the frequency range switch is switched from position to position. It is possible to investigate the response curve of a distributed amplifier from 0.5 to 400 mc in five frequency ranges.

3.6.1 Possibilities of Measuring Error

Video and distributed amplifiers appear as active four-poles with

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low-pass characteristics. Since they contain non-linear elements in the form of amplifier valves, a distortion of the amplified frequencies may occur through overdriving or incorrect design. The effect of distortion, which exists up to 5% in the signal generator output in addition to being possibly caused by the test object, is described in detail under paragraph 9.6.

3.7 Determining the Operating Frequency of a Signal Source

3.7.1 Method of Measurement

The frequency markers of the POLYSKOP are produced through the interference of the POLYSKOP signal generator frequency with the spectral lines produced by the marker frequency generator. If the output frequency of a test signal generator or oscillator is connected to the RF OUTPUT of the POLYSKOP, an interference frequency marker is produced whose position may be compared with one of the markers produced by the POLYSKOP signal generator. In this manner it is possible to check the calibration of signal generators or oscillators after, for example, a valve has been replaced. The accuracy corresponds to the accuracy of the POLYSKOP built-in crystal marker generator. The accuracy is not particularly high ($\pm 1 \times 10^{-4}$), but is sufficient for many purposes.

3.7.2 Test Setup

If the output voltage of the signal source lies roughly around 1 v_{rms}, it may be connected to the EXTERNAL MARKER input at the rear of the POLYSKOP and displayed in the usual manner for external frequency markers. When the FREQUENCY MARKERS control is placed in the "1 MC" or "10 MC" position, the internal frequency markers become visible and may be compared with the position of the appearing external marker. By slowly adjusting the frequency of the signal source, the coincidence of one of the internal spectral lines with the signal source frequency is manifested by a very low frequency interference pattern that is visible across the entire screen.

When the signal source to be tested delivers a small output voltage, it must be connected to the RF OUTPUT of the POLYSKOP. With the OUTPUT ATTENUATOR placed in the "-20 DB" position and one of the vertical-deflection amplifiers placed in the "E_{out}" position, the r-f output voltage of the POLYSKOP is measured. The frequency determination is made by comparison in the same manner as described above.

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To align a receiver local oscillator through any desired tuning range, the frequency sweep width is so adjusted that the total range in which the oscillator is to function is displayed across the screen. The interference indication produced by the oscillator wanders across the screen like an indicator on a scale as the oscillator is tuned through its tuning range.

3.8 Checking the Frequency Calibration on Receivers

The frequency spectrum from 1 to 400 mc can be taken out at the rear of the POLYSKOP to be used in checking the calibration of receivers in this frequency range.

With the FREQUENCY MARKER selector switch in the position "1 MC", the output voltage varies with frequency as follows:

30	mc	to 3	mv
100	mc	to 2	mv
200	mc	to 0.8	mv
300	mc	to 0.2	mv
400	mc	to 0.1	mv

With the FREQUENCY MARKER selector switch in the position "10 MC", the output voltage is:

30	mc	to 30	mv
100	mc	to 3	mv
200	mc	to 2	mv
300	mc	to 1	mv
400	mc	to 0.5	mv

This specification represents only the approximate values and may vary from set to set.

Measured at 20°C ambient temperature, the accuracy of the POLYSKOP marker generator is $\pm 1 \times 10^{-4}$ with a temperature coefficient of $1 \times 10^{-6}/°C$. This limits the realizable accuracy.

3.9 Alignment of Television Receiver Components

The following measurements may be carried out for checking and aligning television receivers:

a) Alignment of r-f tuners in all channels of bands I and III.
b) Alignment of i-f amplifiers (video i-f amplifiers)
c) Alignment of the intercarrier sound sections (i-f section, limiter, discriminator).
d) Alignment of video amplifiers up to the picture-tube connection.
e) Overall check from the VHF input to the picture-tube connection

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with the simultaneous observation of the video response and discriminator characteristic curve.

3.10 Measurements on Antenna Amplifiers

The possibility of covering a wide band of frequencies with a single test instrument is especially advantageous in the development and production of amplifiers for use in community antenna systems. Measurements on these amplifiers for use in the broadcast, shortwave, FM and television bands can be carried out in a very short time.

3.11 Locating Bad Earthing Conditions

The r-f diode probes of the POLYSKOP are well suited for investigating bad earthing conditions because of their high sensitivity.

3.11.1 Test Setup

The test object is connected to the POLYSKOP in the usual manner for measuring the amplitude response. The centre frequency and sweep width are so adjusted that the entire frequency range of the test object is covered.

The r-f diode probe may be used to make checks on the test object to determine the adequacy of the r-f filtering, i.e. that no unwanted r-f voltages are present which may lead to instability. When making alignments, inadequate filtering in multistage r-f or i-f amplifiers causes difficulty in that the calculated pass-band is not attained and the individual stages may have too much gain which may lead to instable conditions.

The same symptoms may appear from a bad choice of earthing points. In some instances, an earth conductor with only a few centimetres of length may cause r-f voltage drops in the order of several millivolts. If the return paths of several circuits are run over the same earth conductor, common earth pickup may cause malfunctioning of the circuits. By measuring the voltage drop between the questionable earth points, such errors are rapidly found.

3.11.2 Possibility of Measuring Errors

With all measurements made with the r-f diode probe, it is imperative that a good connection be made between the diode probe enclosure and the earth of the test object. This is a prerequisite for the accurate

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measurement of the r_f voltage appearing between the electrode of the r-f probe and earth.

3.12 Measurements on Cables, Cable Connectors and Termination Impedances

To aid in the understanding of the following paragraphs over measuring techniques, a review of fundamental concepts will first be given.

If we measure the input impedance of an open-ended high frequency cable as a function of frequency, we observe that at very definite frequencies the impedance becomes almost infinite. As a function of frequency, we obtain the following picture (figure 9).

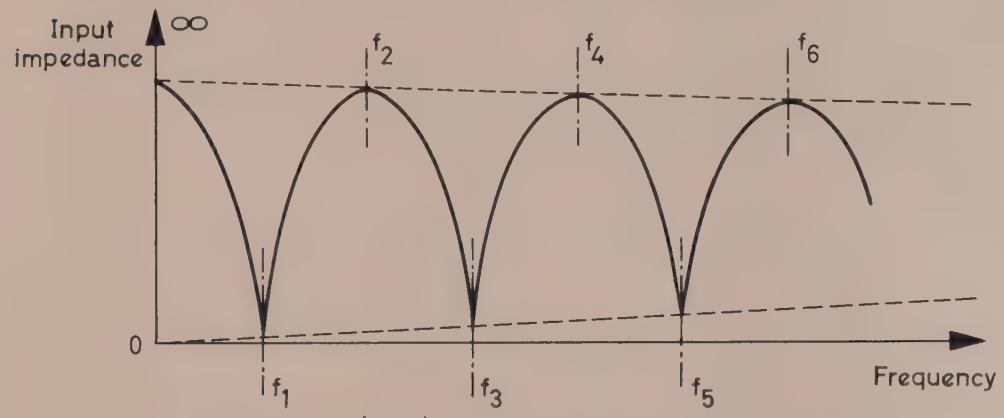

Fig. 9

At zero frequency (d-c), the input impedance is almost infinite. The finite value of the impedance is caused only by the insulation resistance between the inner and outer conductor. With increasing frequency the input impedance decreases and reaches a minimum at f_1. Because of the dielectric losses, the minimum impedance does not reach zero. As the frequency is further increased, a second maximum is reached at f_2, where f_2 is twice the value of f_1. At every integral multiple of f_1, we measure maxima and minima of the input impedance. We observe that the maxima and minima no longer reach the same values that they had at the lower frequencies. This is caused by the fact that the dielectric losses are dependent on frequency and become greater as the frequency is increased.

Repeating the same measurement, but with the cable short-circuited, we measure a very low resistance at zero frequency which is primarily the d-c resistance of the inner conductor. At the frequency f_1, a maximum is obtained where a minimum was for the open-ended cable. Maxima and minima are merely interchanged at the same frequency intervals.

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At what frequency f_1 we find the first minimum in the case of the open-ended cable depends upon its electrical length. The electrical length of the cable may be calculated from the mechanical length, taking into account the dielectric constant of the material between the inner and outer conductor. By determining the frequency f_1 or, for example, the difference between f_8 and f_9, we may calculate the dielectric constant when the mechanical length is known or visa versa.

If we terminate the cable with its characteristic impedance Z_o, we measure always the same input impedance Z_1. In practice, the impedance Z_1 deviates a small amount above and below the Z_o value. To measure a constant Z_1 value, the cable must have the exact same distance between the inner and outer conductors throughout the entire length. In addition, the electrical properties of the insulation material must be also exactly the same throughout the cable length.

The response of the input impedance as a function of frequency is a measure of the cable quality, i.e. the homogeneity of its electrical and mechanical properties.

If we terminate such a cable with a resistor that varies from Z_o as a function of frequency, a wave pattern is displayed which indicates the amount of mismatch. By such measurements, we may recognize the degree of mismatch and then make compensations until the displayed waves are brought to a minimum.

3.12.1 Measuring Technique and Test Setup

A diode is built into the r-f output socket of the POLYSKOP so that measurements on cables may be carried out with ease. The diode measures the output voltage response E_{out} which is then displayed directly on the screen of the picture tube. The large frequency range from 500 kc up to 400 mc makes it possible to carry out measurements on cables as short as 1 metre in length. To make a measurement, the cable to be tested is connected to the RF OUTPUT of the POLYSKOP. The OUTPUT ATTENUATOR is placed in the "-10 DB" position to prevent strong mismatching (more than 30%) of the cable characteristic impedance to that of the POLYSKOP from reacting on the EMF control circuit. The output voltage E_{out} is then displayed as a function of frequency.

3.12.2 Determination of the Characteristic Impedance Z_o

Several metres of the cable to be tested are connected to the RF OUTPUT

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of the POLYSKOP. The sweep width is adjusted to cover the frequency range of the cable. As long as the cable is left open-ended, we see the maxima and minima of the wave pattern as described above. We now terminate the cable with various pre-determined resistance values until one is found that produces a minimum wave pattern. It is important that the terminating resistor is connected as closely as possible to the end of the cable between the inner and outer conductors. This is especially important when measuring at very high frequencies. The terminating resistance found in this manner is equal to the characteristic impedance Z_o of the cable. The Z_o value may be measured within an accuracy of 1% under the condition that a limited-range compensated, variable terminating resistor is used for the usual r-f cables of 50, 60 and 75 ohms. A precision terminating resistor is now in the development stage and may be delivered as an accessory to the POLYSKOP sometime in the near future.

Theoretically, the highest measuring accuracy can only be obtained with an infinite source impedance. Practically, the POLYSKOP source impedance (50, 60, 75 Ω) permits sufficient accuracy to be obtained for the usual r-f cables with Z_o values less than 1000 ohms.

3.12.3 Determining the Dielectric Constant

To determine the dielectric constant, several metres of the test cable are connected to the POLYSKOP, the free end being left open-ended. Beginning with the lowest frequency range of the POLYSKOP, 0.5 to 50 mc, we determine the first voltage minimum E_{out} in the wave pattern which represents the first impedance minimum. For the exact measurement of the frequency f_1, it is recommended that a well calibrated signal generator be connected to the external marker input and the resulting frequency markers be used to measure the frequency at the minimum impedance point. The sweep width should be reduced far enough so that the minimum impedance point may be easily and accurately measured. From the measured frequency f_1 and the mechanical length of the cable, the dielectric constant ε may be calculated from the relationship

$$\varepsilon = \left(\frac{c}{4 f_1 l}\right)^2$$

c = speed of light in metres/sec (3×10^8)

l = mechanical length of the cable in metres

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3.12.4 Determining the Cable Attenuation

The attenuation of a cable is a function of frequency, increasing as the frequency increases. The attenuation, measured at a definite frequency or in the frequency range 0.5 to 400 mc, is easily determined from the POLYSKOP display. To make this measurement it is advisable to use a cable connected between the RF OUTPUT and the RF INPUT of the POLYSKOP that is longer than 10 metres.

The measurement is performed as follows:

(1) Connect the 1-metre precision cable between the RF OUTPUT and RF INPUT.

(2) Set the OUTPUT ATTENUATOR in the "-20 DB" position and the vertical-deflection amplifier selector switch to the position "RF".

(3) With the VERTICAL GAIN control "Y_1", adjust the displayed trace to line 10 on the graticule.

(4) Replace the 1-metre precision cable with the cable to be tested.

(5) Switch back the OUTPUT ATTENUATOR control until the displayed trace is again at line 10.

The difference in the OUTPUT ATTENUATOR settings is equal to the cable attenuation at the adjusted frequency or, as the case may be, at the adjusted frequency range. Since the attenuation of the output voltage can only be made in 10-db and 3-db steps, the measuring accuracy is not very great. By using a separate calibrated attenuator with 1-db switch positions, the accuracy can be improved. The attenuator is then connected between the POLYSKOP r-f output and the cable input.

3.12.5 Determining the Homogeneity

For example in the production of cables, it is possible to monitor the homogeneity of a given length of cable which should be as long as possible. The cable is connected to the RF OUTPUT of the POLYSKOP and terminated with its characteristic impedance provided by a precision terminating resistor. Cables that are not homogeneous produce standing waves which manifest themselves as input impedance variations. The first impedance minimum or maximum at the lowest frequency f_1 permits the point of reflection or discontinuity to be rapidly located.

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3.12.6 Measuring with a Mismatched Cable (matching, reflection coefficient)

The POLYSKOP is suitable for the following measurements in conjunction with a long high-quality test cable available as an accessory with characteristic impedances of 50, 60, or 75 ohms respectively.

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a) Measuring the input impedance of filters, amplifiers, receivers, etc. and compensating mismatch.
b) Measuring the reflection coefficient
c) Testing of cable connections
d) Antenna matching measurements

The characteristic impedance Z_o of the test cable used as a standard does not necessarily have to be equal to the source impedance of the POLYSKOP.

If a high quality cable is connected to the output voltage of the POLYSKOP and terminated with its characteristic impedance, the output voltage E_{out} shows very small variations throughout the frequency sweep. If the cable is terminated with the imput impedance of a test object, the voltage E_{out} varies with frequency indicating the degree of mismatch. In the frequency range with the best matching, the E_{out} wave pattern is at a minimum. Outside of the range of compensation, the E_{out} variations increase (hereafter referred to as E_{out} undulations).

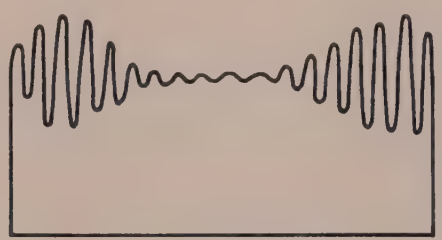

Fig. 10

The magnitude of the voltage undulations of E_{out} is a direct measure of the degree of mismatch or the resulting reflection coefficient.

The simplest method for calculating the reflection coefficient is by measuring the amplitude of the E_{out} voltage undulations at the cable input when the cable is open-ended as well as when connected to the test object. The amplitude of the undulations with the cable open-ended is A_1; the amplitude with the test object connected A_2. The reflection coefficient is then

$$P = \frac{A_2}{A_1}$$

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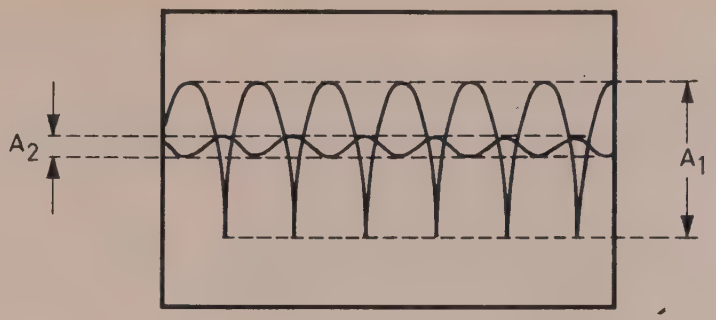

Fig. 11

(When making these measurements, the OUTPUT ATTENUATOR must be switched to the "-10 DB" position)

These measurements have the advantage that the attenuation of the test cable has no effect on the measuring accuracy. The disadvantage lies in the fact that, due to the non-linearity of the POLYSKOP built-in diode rectifier, the amplitude relationship measured is too high, i.e. the calculated reflection coefficient is too small.

A higher measuring accuracy may be obtained in the following manner:

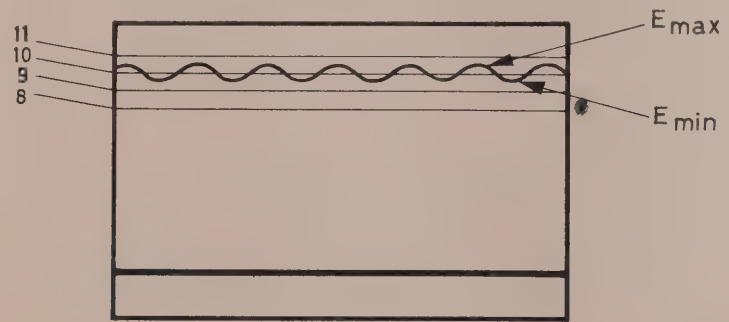

Fig. 12

The maximum and minimum voltages E_{max} and E_{min} displayed on the POLYSKOP represent the transformation of the terminating resistance to the input of the cable. Either E_{max} or E_{min} may be used to calculate the mismatch or the reflection coefficient. The cable maximum and minimum input impedances Z_{max} and Z_{min}, which are purely resistive, are calculated from the fact that the signal generator emf E_o is divided between the generator source resistance R_i and the cable input impedance in a simple ohmic relationship.

The resulting equations are

$$Z_{max} = R_i \frac{E_{max}}{E_o - E_{max}} \qquad \text{or} \qquad Z_{min} = R_i \frac{E_{min}}{E_o - E_{min}} \qquad (\Omega)$$

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From the value of Z_{max} or Z_{min}, the reflection coefficient P may be calculated.

$$P_2 = \frac{Z-R_i}{Z+R_i} \qquad Z = Z_{max} \text{ or } Z_{min}$$

For fast measurements with the POLYSKOP, the above equations are changed into another form as follows:

We adjust the POLYSKOP so that the undulations of the E_{out} curve lie symmetrical to the line 10 on the POLYSKOP graticule. From the maximum value of the indicated voltage E_{max} or the minimum value E_{min}, we are able to calculate Z_{max} and Z_{min}. The value of the signal generator emf (E_o) is important for the calculation. The scale value may be taken as 20 for the case where the cable impedance Z_o matches the POLYSKOP source resistance R_i. Since this is not always the case because we want to measure different types of cables, a tabulation is given of the E_o scale value for each impedance combination between the POLYSKOP and the test cable.

		Source Impedance of POLYSKOP (Ω)		
		50	60	75
Cable Z_o (Ω)	50	20	22	25
	60	18.3	20	22.5
	75	16.7	18	20
	150	13.3	14	15
		E_o Scale Value		

For other cables, the following formula may be used to calculate the E_o scale value:

$$E_o = \frac{10\ (R_i + Z_o)}{Z_o}$$

From the measured value of E_{max} obtained from the POLYSKOP graticule, to use a numerical example, say 10.7, we calculate Z_{max}

$$Z_{max} = \frac{E_{max}}{E_o - E_{max}} R_i \qquad \text{e.g.} \quad Z_{max} = \frac{10.7}{20 - 10.7} 60 = 69\ \Omega$$

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In the same manner we may calculate Z_{min}. From the value of Z_{max} we may calculate the reflection coefficient P

$$P = \frac{Z_{max} - Z_o}{Z_{max} + Z_o} \qquad \text{e.g.} \quad P = \frac{69 - 60}{68 + 60} = 0.07 = 7\ \%$$

The above calculations give results as long as the reflection coefficient lies under 20% and the test cable attenuation at the frequency of measurement may still be neglected.

For example, if we measure 40 metres of precision cable at 200 mc, we must take into account that the r-f voltage reflected from the end of the cable reaches the cable input at a lower value because of the cable attenuation. For instance, in the example of paragraph 3.12.4 where the cable attenuation was found to be 3 db at 200 mc, the E_{out} undulations produced by the reflected voltage would be reduced by 2 x 3 = 6 db, or to one-half of the value obtained from a cable with no attenuation. In the above numerical example, the displayed undulations would vary twice as far from the reference line 10, i.e. from 10.7 to 11.4, if the cable under test had no attenuation.

$$Z_{max} \text{ then equals } \frac{11.4}{20 - 11.4}\ 60 = 80\ \Omega$$

$$\text{so that } P_2 = \frac{80 - 60}{80 + 60} = 0.14 = 14\ \%$$

Here we see that the true reflection coefficient of a cable with 2 x 3 = 6 db attenuation actually is greater by a factor of 2.

3.12.7 Determining the Phase Angle of the Reflection Coefficient

The phase angle φ of the reflection coefficient can be determined with fairly good accuracy. To make this measurement, the cable is first driven open-ended. The frequency difference of two minima f_1 is measured. The test object is then connected and the entire curve of maxima and minima is displaced. The frequency displacement for the same minimum point is designated as f_2. From the two values f_1 and f_2, we may calculate the phase angle of the reflection coefficient.

$$\varphi = 2\pi \frac{f_2}{f_1}$$

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When the OUTPUT ATTENUATOR is in the position "0 DB", a mismatch of around 30% may react upon the EMF control circuit of the POLYSKOP and cause a measuring error. Always check the EMF in this case to see that the control circuit is not being influenced. When the OUTPUT ATTENUATOR is in a position greater than "-10 DB", there is no influence upon the EMF control circuit even with mismatches up to 100%.

Low level input stages can be easily overdriven with an excessive input voltage which gives the same indication as a large mismatch. For these type of measurements, it is advisable to set the OUTPUT ATTENUATOR in the position "-20 DB". In this case, 50 mv_{rms} are applied to the test object, thus causing no danger of overdriving.

4. How Measuring Errors Can Be Avoided

The possibilities of measuring error have been pointed out in the handling of various application examples. The important points are brought together once again to form a compilation of rules to be observed when using the POLYSKOP.

4.1 Measuring Errors Caused by Using an Excessive Sweep Width

Inherent in the automatic frequency sweep of the POLYSKOP is the relatively short time that the measuring frequency dwells in the pass-band of the test object. When measuring test objects with very small bandwidths or when the frequency sweep width is quite large, the dwell time is so short that the test object cannot give its full amplitude response. In this case the bandwidth as well as the resonant frequency of the test object is not correctly measured. The simplest test to see if the test object is responding to its full amplitude is to reduce the sweep width. If no change is observed in the height of the amplitude display or in the position of the resonant frequency on the frequency scale, you may be certain that there is no measuring error. For details on the problem of resolving high Q resonant circuits and sharp cut-off filter responses, please read under section 9., and particularly paragraph 9.5.

4.2 Overdriving the Test Object

Always make certain that the POLYSKOP output voltage does not exceed the maximum permissible input voltage of the test object. By overdriving, the frequency response is distorted and measuring errors are possible.

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4.3 Measuring Errors Caused by Distortion

The response of video amplifiers and low-pass filters, as well as of low Q band-pass filters can be measured with an accuracy that is limited by the distortion created in the POLYSKOP. The measuring errors produced may be held small when the measured voltage applied to the r-f diode probe or RF INPUT is as high as possible with peak-value rectification still being assured. Steps up to 10% in the frequency response at one-half of the limit frequency of the test object can be caused by a distortion of about 5% (see paragraph 9.6). Distortion may be caused to even a greater extent by the test object itself when dealing with a c t i v e four-poles.

4.4 Hum and RF Pickup

You must always be careful that a good earth connection is made between the test object and the enclosure of the diode probe. At the higher frequencies, under no circumstance use a thin, long conductor for earth connections. No changes in indications should be permitted when the diode probe is moved about. Also in other measurements, no fluctuations in indication should be tolerated when the test setup instruments and cables are moved. It is necessary to remove all pieces of equipment in the test setup from earth connections except the POLYSKOP. Expecially sensitive in this respect are test objects with high amplification and undefined r-f earth relationships.

If the test object already contains a rectifier circuit, whose output is to be measured on the POLYSKOP, measuring errors may be caused by hum pickup. This hum synchronized to the a-c supply frequency is recognized by a shifting of the displayed response curve as the centre frequency is varied. A distortion in the form of the displayed curve is a sure indication of hum pickup.

4.5 Measuring Errors Caused by Overdriving the Vertical Deflection Amplifier

Care should be taken that the displayed curve projects at no position above the upper limit of the picture-tube screen since indication errors are caused by overdriving the vertical-deflection amplifier. If the right side of the display is moved below the 0-reference line when the Y-deflection amplifier gain is increased (control (17) or (18)), this is a sure indication of overdriving. When using a double display, the overdriving of one amplifier disturbs the indication of the other amplifier.

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When switching the selector switch (15) or (16), for example, from a position for diode probe measurements to the position "EMF" where a large change in amplitude takes place, the Y-deflection amplifier can be so overdriven that it takes a few seconds before the amplifier valves re-establish their operating points. In such cases it is advisable to turn the appropriate gain control back to zero, wait a few seconds and then slowly increase the gain to the desired value.

4.6 Measuring Errors Caused by Oscillator Pickup

If the output of the POLYSKOP is fed into the mixer stage of a receiver, it is possible that the receiver oscillator voltage may couple over into the POLYSKOP output circuit and affect the EMF control circuit or the E_{out} response indications. The effect on the EMF control circuit is reduced by switching in more attenuation. It is very difficult to prevent the E_{out} response from being affected in such cases; the other circuits of the POLYSKOP are not influenced.

4.7 The POLYSKOP is not suitable for the following measurements

a) Measurements on test items with least-bandwidths less than 50 kc, for example, crystal filters or multistage narrow band i-f amplifiers (even if the pass-band is greater than 50 kc) because of the extremely sharp slopes of their response curves.

b) Measurements with sweep widths less than ±200 kc.

c) The POLYSKOP is no spectrum analyzer. It cannot be used as a selective amplifier to measure the spectral energy distribution in definite bands without special accessories.

d) The POLYSKOP is no frequency measuring device of the highest accuracy. For particulars over the obtainable accuracy in frequency measurements, please read paragraph 3.8

e) The POLYSKOP is no impedance measuring device in the exact sense of the word. For determining impedances in absolute value and phase, the ROHDE & SCHWARZ Z-g Diagraph Type ZDU is recommended. To make impedance matching measurements of limited accuracy with the POLYSKOP, please read paragraph 3.12.

f) No pure frequency can be taken from the POLYSKOP. Even when the sweep-width control is completely turned back, a frequency sweep of approx. 50 kc still remains, plus a slow frequency drift caused by fluctuations in the operating voltages.

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5. Circuit Description

The POLYSKOP Type SWOB is a wide-sweep signal generator containing a double-display oscilloscope. The sweep of the signal generator and the horizontal deflection of the oscillographs occur at the same alternating current rate. They are connected to the a-c supply frequency which establishes the fixed phase relationship. The frequency-dependent variable (mostly the amplitude response) is used to drive a vertical deflection amplifier.

The POLYSKOP mainly consists of four sections:

(1) Signal generator section
(2) Vertical deflection amplifiers with picture tube
(3) Marker generator
(4) Power supply

5.1 Signal Generator Section

The signal generator section of the POLYSKOP contains five frequency ranges:

0.5	to	60 mc
50	to	150 mc
150	to	220 mc
220	to	310 mc
310	to	400 mc

The r-f voltages are produced in single stage oscillators except in the 0.5 to 50 mc range. Each frequency range is provided with a separate oscillator (Rö 8 and Rö 9). The range change is brought about by switching the anode supply voltage to the appropriate oscillator valve and connecting its r-f voltage to the output of the set by means of a relay (RLS 1, 2, 3 and 8). The oscillators function in a Colpitts circuit using the valve anode grid capacity. The tank circuit inductance consists of a small ferrite-rod core placed between the pole shoes of an a-c electromagnet. The ferrite-rod core receives a magnetization since it lies in the path of flux produced by the "driver coil" of the electromagnet.

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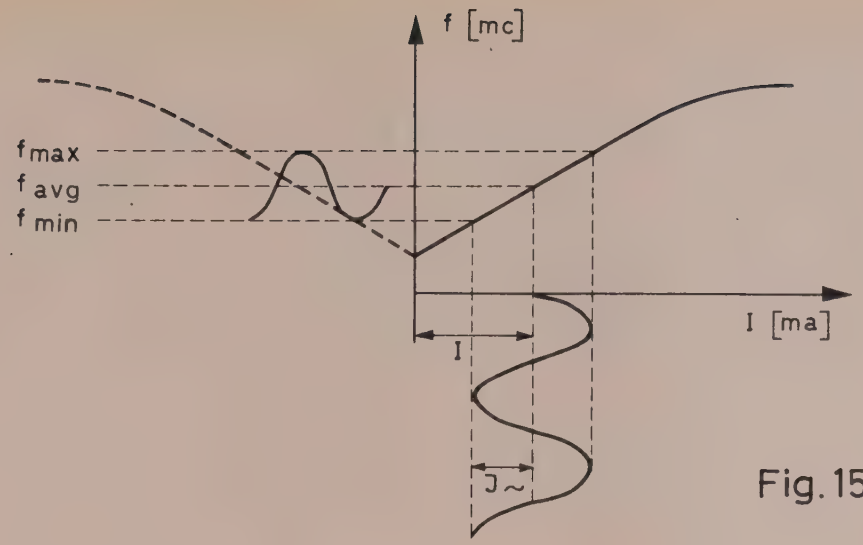

Fig. 15

As can be seen from Fig. 15, the centre frequency is dependent upon the direct current that flows through the driver coil. The frequency sweep is dependent upon the alternating current that is superimposed upon the direct current. In the POLYSKOP, the direct current is applied to the switched-in driver coil over the centre frequency control (R 70) and the resistor R 71. The alternating current is brought in over the sweep width control R 69 and the coupling capacitors C 64 and C 65.

If the peak value of the alternating current exceeds the value of the direct current, the current in the driver coil goes through zero and increases again in the reversed direction (see Fig. 16). The frequency of the sweep generator reaches its lowest point at the current value zero. A further increase in current in the negative direction causes the frequency to rise again instead of dropping. Since this operating condition easily leads to measuring errors, the beam of the oscilloscope is blanked out as soon as the frequency sweep width limit is exceeded.

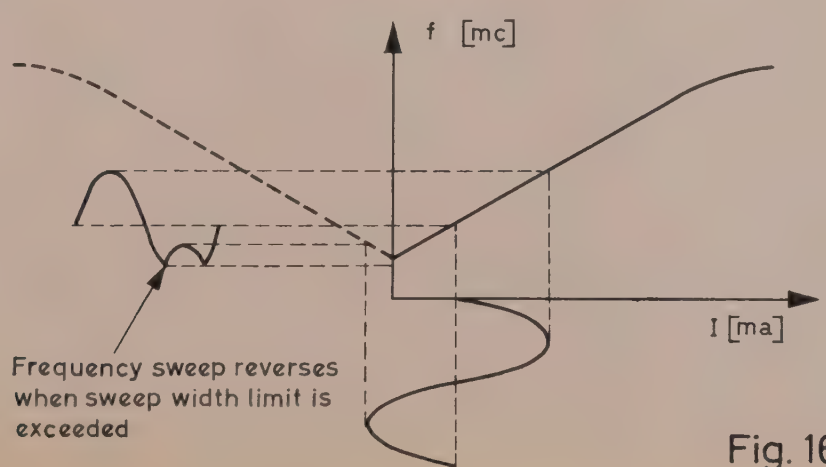

Fig. 16

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The difference frequency is amplified by a three-stage wide-band amplifier (Rö 2 to Rö 7) and then delivered to the r-f output of the POLYSKOP. The last of the three stages is a distributed amplifier using four valves.

A resistive attenuator is placed before the r-f output that permits the output signal to be reduced in 10-db steps to a maximum of -60 db. In addition, there is a 3-db attenuator actuated with the "3 db" button which reduces the signal 3 db.

A rectifier circuit (Gl 8) is connected directly in the r-f output. The rectified r-f output voltage response can be viewed on the picture tube. (Selector switch for Y_1 or Y_2 in the position E_{out}.)

Since the oscillators have a rather large amplitude response (up to 30%) as they are swept across their frequency range, it is necessary to hold the output voltage constant by means of a control circuit. This control circuit operates in the following manner: (see Fig. 17)

The r-f voltage is rectified by Gl 2 just ahead of the calibrated output attenuator. The rectified voltage is applied through R 53 to the control grid of valve Rö 12 (type EF 804 s) to which, through R 85, R 86, -85 v are also applied. The resistances R 53, R 85 and R 86 make up a voltage divider which is so adjusted that valve Rö 12 is cut off when rectifier Gl 2 delivers no output voltage. The anode of Rö 12 is connected to the grid of a double triode (Rö 11, type ECC 81) which has both its halves connected in parallel. This double triode is connected in series with the anode current delivered to the switched-in sweep oscillator. When Rö 12 is cut off, there is no voltage drop across R 83. The grid of Rö 11 becomes highly positive causing it to have a low d-c anode resistance. The sweep oscillator thereby receives a high anode voltage causing it to oscillate quite strongly. Gl 2 then delivers a positive voltage and Rö 12 draws anode current. The anode voltage of Rö 12 drops, thereby decreasing the bias voltage of Rö 11. The valve Rö 11 increases its d-c anode resistance and the anode voltage of the sweep oscillator drops. The anode voltage and the r-f voltage adjust themselves to such a point where equilibrium is established. Any change of the r-f voltage level is compensated through the control amplifier by changing the anode voltage to the sweep oscillator which changes its r-f voltage level. An error signal is necessary for the functioning of the control circuit amplifier. This error signal makes a slight change in the r-f voltage level necessary. The r-f voltage level changes become smaller the larger the

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One side of all the driver coils is connected to a common point and fed to earth through the silicon diode Gl 7. The common point is also connected to the grid of Rö 10 R through the resistor R 79 (300 kΩ). The anode of Rö 10 R is connected to the anode supply voltage through resistor R 77 (100 kΩ) in addition to being connected to the cathode of the picture tube. In normal operation, the current through the rectifier Gl 7 is always positive. The voltage drop is quite small creating a grid bias voltage at valve Rö 10 R that is practically 0 volts. The anode, which is connected to the cathode of the picture tube, establishes a voltage potential between 50 and 60 v with the load resistance used. If the peak value of the alternating current through the driver coil exceeds the value of the direct current, the current direction through the rectifier Gl 7 is reversed. Since the current through Gl 7 is now passing in the high resistance direction, the negative voltage drop drives the valve Rö 10 R to cut-off. The anode voltage of Rö 10 along with the cathode of the picture tube rises to the anode supply voltage of about 200 v. The beam of the picture tube is thereby cut off at the point where the sweep width exceeds its limit (Fig. 16).

The sweep frequency occurs at the a-c supply frequency. Transformer Tr 2 delivers the a-c voltage for the driver coil and the horizontal beam deflection of the picture tube. An RC filter (R 67, C 63) is connected in the primary circuit of the transformer in order to suppress the harmonics of the a-c supply voltage. The resistor R 67 is variable and serves to adjust the primary voltage to the correct value. In addition, the transformer delivers an a-c voltage that is used for cutting off the oscillators during the return trace and for driving the electronic switch for the vertical-deflection amplifiers.

The r-f voltage of the first range 0.5 to 50 mc is not directly, but indirectly, produced through mixing. The r-f voltage of the swept oscillator (valve Rö 8 L) operating in the range from 150 to 220 mc is mixed with the output voltage of a 150-mc fixed frequency oscillator. (The swept oscillator delivers its voltage directly to the POLYSKOP output when the set is switched to the 150 to 220 mc range.) The fixed frequency oscillator (Rö 1) is designed as a push-pull circuit in order to suppress the second harmonics. The difference frequency appearing at the mixing diode is

$$\begin{array}{r} 150 \text{ to } 220 \text{ mc} \\ -\ 150 \qquad 150 \text{ mc} \\ \hline 0 \text{ to } 70 \text{ mc} \end{array}$$

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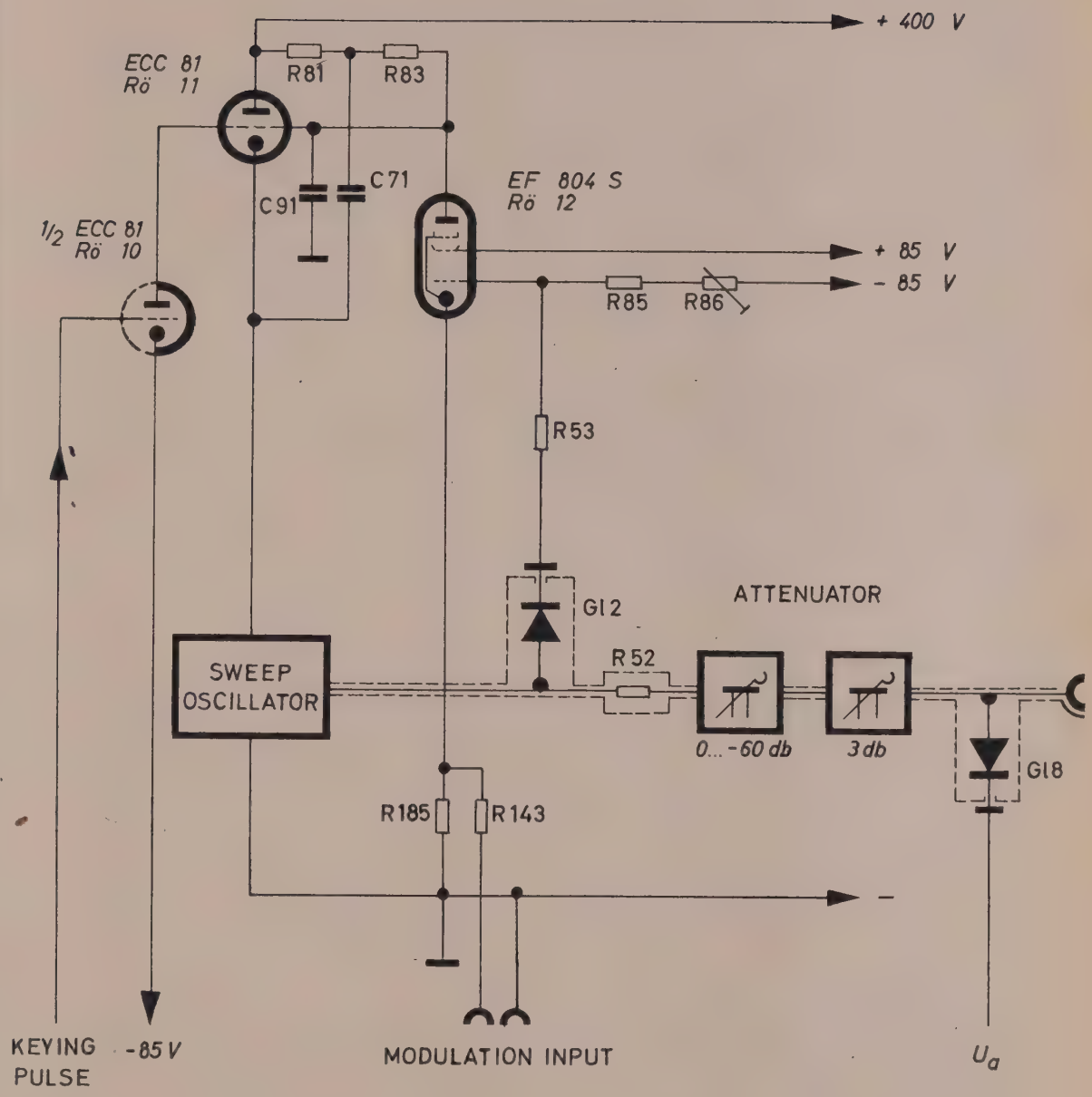

CONTROL AMPLIFIER AND KEYING CIRCUIT

POLYSKOP

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Fig. 17

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control amplifier gain is. The control amplifier gain is determined solely by Rö 12 since Rö 11 operates as a cathode follower having a gain less than 1.

In order to change Rö 11 into a normal amplifier for fast changes (a-c variations), the anode resistance of Rö 12 (R 81 and R 83) is tapped and connected by C 71 (16 µf) to the cathode of Rö 11. The amplifier stage Rö 11 then has a gain of approx. 10 for a-c variations. A prerequisite for the faultless operation of this circuit is that the anode resistance of Rö 12 is very high so that the anode current through R 83 is independent of the anode voltage of Rö 12. This requirement is reasonably satisfied with an anode resistance of 2 MΩ. The control amplifier compensates slow changes of r-f voltage level (for instance when frequency bands are changed) with much less accuracy than for the fast variations encountered in frequency sweeping.

To check the operation of the control amplifier, the voltage output response of Gl 2 can be viewed with the Y_2 selector switch placed in the position "EMF".

The control amplifier does not only compensate the r-f voltage level variations caused by amplitude response, a-c supply variations, range changing, etc. (internal causes), but also those which are caused by load variations. In other words, the internal resistance of the generator is very low (almost zero) as a result of the control circuit. In order to obtain a source impedance equal to a characteristic impedance of 60 Ω, a 60-Ω resistor (R 52) is connected behind the rectifier Gl 2 in the output circuit.

The frequency sweep, horizontal deflection and oscillator keying are all synchronized to the a-c supply frequency in such a way that an increase in frequency of the sweep oscillator corresponds to a horizontal beam deflection from left to right on the screen of the picture tube. The frequency at any instant corresponds to a definite position of the beam in the horizontal direction. During the return time of the trace and frequency, the oscillator is cut off in order to give the display a 0-reference line. The oscillator must be cut off at the maximum frequency point when the beam is in the farthest position to the right in the display. The oscillator is cut in again at the lowest frequency point to the left in the display. A square-wave voltage is necessary for keying the oscillator. The edges of the square-wave coincide with the maxima and minima of the a-c supply voltage.

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The keying voltage is produced in the POLYSKOP by limiting the sine-wave voltage delivered from transformer Tr 2. Since the edges of the square wave through the limiting action coincide with the zero voltage points of the sine wave, the sine-wave voltage must be changed in phase by 90 degrees before limiting in order to obtain the desired phase relationship. The 90-degree phase shift is produced in the phase-shift network R 73, R 74, C 69. R 73 is used to adjust the phase shift. The sine-wave voltage is square-wave limited in the left section of Rö 10 whose cathode lies at -85 v and whose anode is connected to the grid of the control valve Rö 11. During the forward frequency sweep, Rö 10 L is cut off and Rö 11 can function normally. During the return sweep, Rö 10 L is conducting, which drops the anode voltage to a low value (about 30 to 40 v) because of the high anode load resistance (R 83 = 500 kΩ). Since the cathode of Rö 10 L lies at -85 v, the anode of Rö 10 L has a potential of about -40 to -50 v with respect to earth. The anode of Rö 10 L is connected to the grid of Rö 11 which gives them the same potential. Rö 11 is thereby fully cut off and the sweep oscillator stops oscillating.

For special measuring problems, it may be useful to amplitude-modulate the r-f output signal. For this purpose, a modulation input is provided. The modulating signal is applied to the control amplifier whose feed-back action makes it possible to produce an almost distortion-free modulation up to about 30%.

5.2 Display Section

The display section has the purpose of displaying the amplitude response of various test items as a function of the sweep oscillator frequency. R-f signals must be changed into their proportional d-c values before they can be displayed. It is therefore necessary to have additional equipment for measuring reflection coefficients, response curves, etc. which produce d-c voltages by simple rectification.

For this purpose, the r-f terminating socket is provided. The r-f signal, which has passed through the test item, is passed on to the terminating socket and may be displayed by placing the Y_1 selector switch in the position "RF". For signals that are already rectified in the test item (for example, the demodulator of a receiver or a diode probe), separate vertical-deflection amplifier inputs are provided. Since the demodulated signal of a test item may be either positive or negative, the polarity of the vertical-deflection amplifier inputs

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may be selected for either positive or negative signals so that an upright picture may always be presented. In order to have the possibility of observing two voltage variables simultaneously, the double-channel vertical deflection amplifier system is provided with an electronic switch.

The vertical deflection amplifiers must have a few special characteristics not found in normal oscilloscope amplifiers. When tracing a linear frequency response curve, the input voltage to the amplifier is a constant value during the forward trace and zero during the return trace. The forward and return trace each last 10 msec. The amplifier must then be able to handle a square wave at the a-c supply frequency without any noticeable sag. The lower limit frequency must be extremely low (approx. 0.2 cps). The time constants of the coupling circuits lie at 1 sec and even higher. A voltage stabilizer cell ("Neumannzelle") is connected as a cathode resistor to provide the bias voltage for the first stage. This cell has an equivalent capacity of 40,000 µf. The screen-grid voltage is produced by a relatively low resistance divider network that uses no by-passing.

The next stage (Rö 21 and Rö 15 Type ECC 81) is a phase splitter that produces two signals of opposite polarity. The polarity may be selected by means of relay RLS 6 and RLS 7, respectiveley. The following stage is again a double triode with a common cathode. In the left section, the signal is amplified; the right section serves as cathode follower for the switch-over pulse in double-display operation. Up to this stage, both channels Y_1 and Y_2 are identically constructed. The electronic switching in double-display operation is accomplished by Rö 22 and Rö 16. The anodes of the left sections of these valves are connected together and have a common anode load resistor. The grids of the right sections are each connected to one of the switch-over pulses delivered from a bistable multivibrator (Rö 23). In normal oscilloscopes, the vertical-deflection amplifier is usually designed as an a-c amplifier which is fully adequate for displaying symmetrical signals. The situation is different in the case of oscilloscopes designed to display the response curves obtained by the sweep frequency method. Not including exceptions (discriminator curves), the oscillograph pattern is displayed to one side of the 0-reference line, i.e. the signal is not symmetrical and contains a d-c component. If the d-c component is not passed through the amplifier, the 0-reference line has a position that is dependent upon the constant of the signal

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displayed. For example, if during an alignment procedure the height or width of the displayed response curve changes, the 0-reference line is displaced vertically. This is very disturbing when trying to evaluate a displayed quantitiy on a graticule.

In order to avoid this disadvantage, a symmetrical clamping circuit is used which is keyed in synchronism with the sweep frequency. During the return trace, the resulting 0-reference line is held exactly to a definite voltage level. Rö 17 (Type EAA 91) serves as the clamping diode. After the signal is clamped, it cannot be permitted to pass through any more RC-coupling networks. For this reason, the last two stages are designed as a d-c amplifier (Rö 18 L and Rö 19). The vertical deflection coils L 22 lie in the anode circuit of Rö 19.

Since the anode current only flows in one direction in a valve, it is possible to deflect an electron beam only in one direction from the picture-tube middle. In order to utilize the entire screen for the display, a current is passed through the deflection coils that has the opposite direction to the current passing through the valve Rö 19. This current is fed in over R 164 which deflects the beam somewhat over the lower edge of the screen. In this manner the beam may be deflected over the entire picture-tube screen with the anode current of Rö 19. The current for the negative deflection of the beam is supplied from the unstabilized HT voltage of the electronically stabilized power supply (approx. 400 v). This voltage is naturally subject to a-c supply voltage variations which affects the negative deflection current. The picture-tube pattern is displaced in the vertical direction with a-c supply voltage variations. In order to eliminate this undesirable effect, a small additional current is brought over from the HT voltage through R 188 and fed into the anode circuit of Rö 18. Any change in the HT voltage causes a change of operating point, thus changing the anode current of Rö 19 which counteracts any change in the negative displacement current.

Clamping circuit and electronic switch.

As already mentioned, the clamping circuit serves to fix the 0-reference voltage level. The circuit operates in synchronism with the frequency sweep and is controlled by the oscillator keying voltage. This keying voltage is taken from the grid of the keying valve (Rö 10 L) and fed to the grid of Rö 25 R whose cathode lies at -85 v potential, the same as Rö 10 L. The anode of Rö 25 R is connected to

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the grid of Rö 25 L whose anode circuit resistance is made up of two equal resistors; one connected to the anode, the other to the cathode. The keying pulse brings Rö 25 R into conduction. Because of the high anode load resistance, the anode voltage drops to a low value (approx. 30 v). Since the cathode lies at -85 v, the anode of R 25 R drops to about -50 v with respect to earth. The grid of Rö 25 L also has the same potential of -50 v which drives it into cutoff. The anode voltage of Rö 25 L rises toward 250 v and the cathode voltage drops to earth or 0 v. When the keying voltage is removed (during the forward sweep), Rö 25 R is cut off. The grid of Rö 25 L rises to the anode supply potential through the anode load resistor R 194. Rö 25 L conducts. Two square-wave voltages of opposite phase are available at Rö 25 L that are in phase with the keying voltage. These square-wave voltages are applied to the series connected diodes in Rö 17 through capacitors C 83 and C 84. The diodes rectify the square-waves; a pulsating d-c voltage is created across potentiometer R 168. The phase relationship is so chosen that the diodes are conducting when the sweep oscillator is cut off during the return trace. Since the diode forward resistance is quite low, all of the electrodes of the duo-diode have practically the same voltage level, namely the level adjusted at R 167 which is applied to the arm of potentiometer R 168. Any difference in diode characteristics can be compensated with R 168. The point of common connection between the diodes is connected to the input grid of the d-c amplifier (Rö 18 L). During the clamping action, this grid is connected to the voltage level adjusted at R 167 through the low resistance of the conducting diodes. The grid has thereby a definitely fixed potential during the return trace giving a definite position to the 0-reference line on the picture tube. During the forward sweep or trace, the diodes are cut off so that the grid of Rö 18 L can be driven by the signal without being influenced by the diode circuit. Since there is no grid resistor a coupling capacitor (C 82) of 1000 µµf is sufficient in spite of the extremely low limit frequency. A grid resistor is not necessary since wandering of the grid potential is not possible as a result of the clamping action.

In double-display operation, the delivered signals to the two amplifiers are alternately switched in so that the signals are displayed every other frequency sweep. This is noticeable in the display by a decrease in brightness accompanied with flicker. The switch-over from one channel to the other is always accomplished at the end of

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the forward sweep. The clamping circuit then has sufficient time (10 msec) to charge the coupling capacitor C 82 to the 0-reference level of the other signal. The switch-overs occur at 1/2 the a-c supply voltage frequency.

The switch-over pulses are produced in the following manner:

The clamping pulses are taken from the cathode of Rö 25 L and coupled to the grid of Rö 24 R through capacitor C 94. In valve Rö 24, the pulses are amplified and limited. The square-wave pulses are differentiated with the RC network of C 99-R 207 and fed to Rö 24 L. Rö 24 L is normally cut off by the negative voltage obtained from the voltage divider R 206-R 207. Only the positive peaks of the differentiated square-wave cause the valve to conduct and produce a negative needle pulse across the anode resistance R 208. Since the anode voltage of the bistable multivibrator Rö 23 is taken from the anode of Rö 24 L, the multivibrator is triggered. The bistable multivibrator (flip-flop) has two stable conditions, i.e. one valve section conducting while the other is cut off. The system changes from one stable condition to the other with every trigger pulse. The circuit is so designed that at the point between R 165 and R 199, the voltage varies between -15 v and +50 v with respect to earth. At the point between R 204 and R 205, the same voltages appear, but with opposite polarity. Rö 16 R and Rö 22 R are both driven with these voltages. For example, if the grid of Rö 22 R lies at -15 v, this section is cut off and Rö 22 L can operate as a normal a-f amplifier. If the grid lies at +50 v, Rö 22 R conducts a heavy anode current and its cathode potential rises to about +55 v. The cathodes of both sections of Rö 22 are connected together, therefore Rö 22 L has a bias voltage of approx. -50 v (grid voltage to earth, about +8 v). This cuts the valve off even for signals with large amplitudes. The same is true for the functioning of Rö 16. The input signals are alternately delivered to the common anode lead resistor R 138. If one of the amplifier channels is shut off, the electronic switch becomes superfluous. One of the cathodes of Rö 23 is switched open so that the appropriate system is not conducting and the multivibrator does not respond to the trigger pulses. The unused channel remains cut out of operation. The cathodes of Rö 23 and Rö 24 are connected in pairs so that when one cathode of Rö 23 is switched open, so is one of the cathodes of Rö 24. In this manner, the trigger itself is also switched out which is bothersome in single channel operation.

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5.3 The Marker Generator

The marker generator is used for frequency orientation when evaluating an oscillogram. 1-, 10- and 50-mc markers may be selected.

The crystal oscillator with Rö 26 L is connected in a Colpitts circuit which generates a 1-mc and 10-mc fundamental frequency. The crystals are changed by relay RLS 4. The generated oscillations are amplified in Rö 26 R whose anode circuit is switched between a 1-mc and 10-mc tuned circuit. The 10-mc circuit contains no special capacitor, the valve and wiring capacity being used.

The oscillator with Rö 26 R is switched over to a Colpitts oscillator generating a 50-mc frequency by means of relay RLS 5. (C 113-L 36-C 114). The 10-mc tank coil L 35 is then used as an anode choke while Rö 26 L is out of operation. The generated frequency is fed to Rö 27 which operates as a harmonic generator. The diode Gl 10 connected parallel to inductor L 37 aids in the harmonic generation. In Rö 28 the signal is again formed for harmonic generation. The harmonic spectrum now reaches up to 400 mc and is fed to the mixing diode Gl 12. A small part of the signal generator output voltage is coupled out over R 51 for mixing. Each time the signal generator passes through a harmonic frequency, interference is produced. This interference frequency is amplified through the two stages of Rö 29. The RC network of C 133/R 248/C 134/R 247 as well as C 132/R 251 is used to produce a favourable marker form. The markers are amplified once more by Rö 18 R and coupled into the vertical deflection amplifier channel through C 85.

5.4 Power Supply

The valve filaments are heated with an unstabilized a-c voltage of 6.3 v, except for Rö 8 and Rö 9. There are three circuits used to supply the necessary filament current. One side of the filaments in the signal generator section is connected to the chassis so that the filament current is carried by a single conductor from the winding 5-6 of Tr 1. The filament current for the vertical-deflection amplifier section is carried by two conductors from winding 3-4 with the filament circuit being earthed at only one point. The cathodes of valves Rö 11, Rö 30 and Rö 31 have a high d-c potential over earth. These valves are supplied from a separate filament winding 1-2 which is not fixed at any potential. However, due to small currents through the cathode-filament insulation, the filament winding approaches the cathode potentials.

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The two r-f generator valves Rö 8 and Rö 9 are heated from a stabilized d-c supply to increase the valve life and provide a higher stability. Approximately 12 v are obtained from the bridge-rectifier Gl 13 which is connected to winding 15-16 of Tr 1. This voltage is fed to a transistor stabilizing network comprising of T 1, T 2 and T 3. The reference voltage for the voltage stabilization is provided by a Zener or breakdown diode Gl 14. The adjustment of the heater voltage is made with potentiometer R 258.

The anode supply voltage (approx. 205 v) of the valves in the signal generator section and marker generator is not stabilized. This voltage is provided by Gl 5/C 61/L 30/C 62. Stabilization is not necessary since the EMF control circuit holds the r-f output voltage constant anyway.

The anode supply voltage of the display section (250 v) is stabilized by the circuit containing Rö 30, Rö 31, Rö 32 and Rö 33. The HT voltage (approx. 400 v) feeding the regulator circuit is supplied through the bridge-rectifier Gl 4. The negative side of the filter capacitors are not earthed, but connected to corresponding points on the plus side of the 205-v anode voltage supply. By this means, normal electrolytic capacitors may be used in spite of the 400-v HT voltage.

The high voltage for the picture tube (approx. 4 kv) is produced by a voltage-doubler circuit using cartridge-type selenium rectifiers which are supplied with 1.7 kv a-c.

The -85 v which is necessary at several points in the set is supplied with the circuit comprising of Gl 6/C 67/R 72/C 68. This voltage is stabilized with the reference tube Rö 34 (Type 85 A 2).

A blower is built in at the rear of the set which provides protection against excessive temperatures during prolonged operation.

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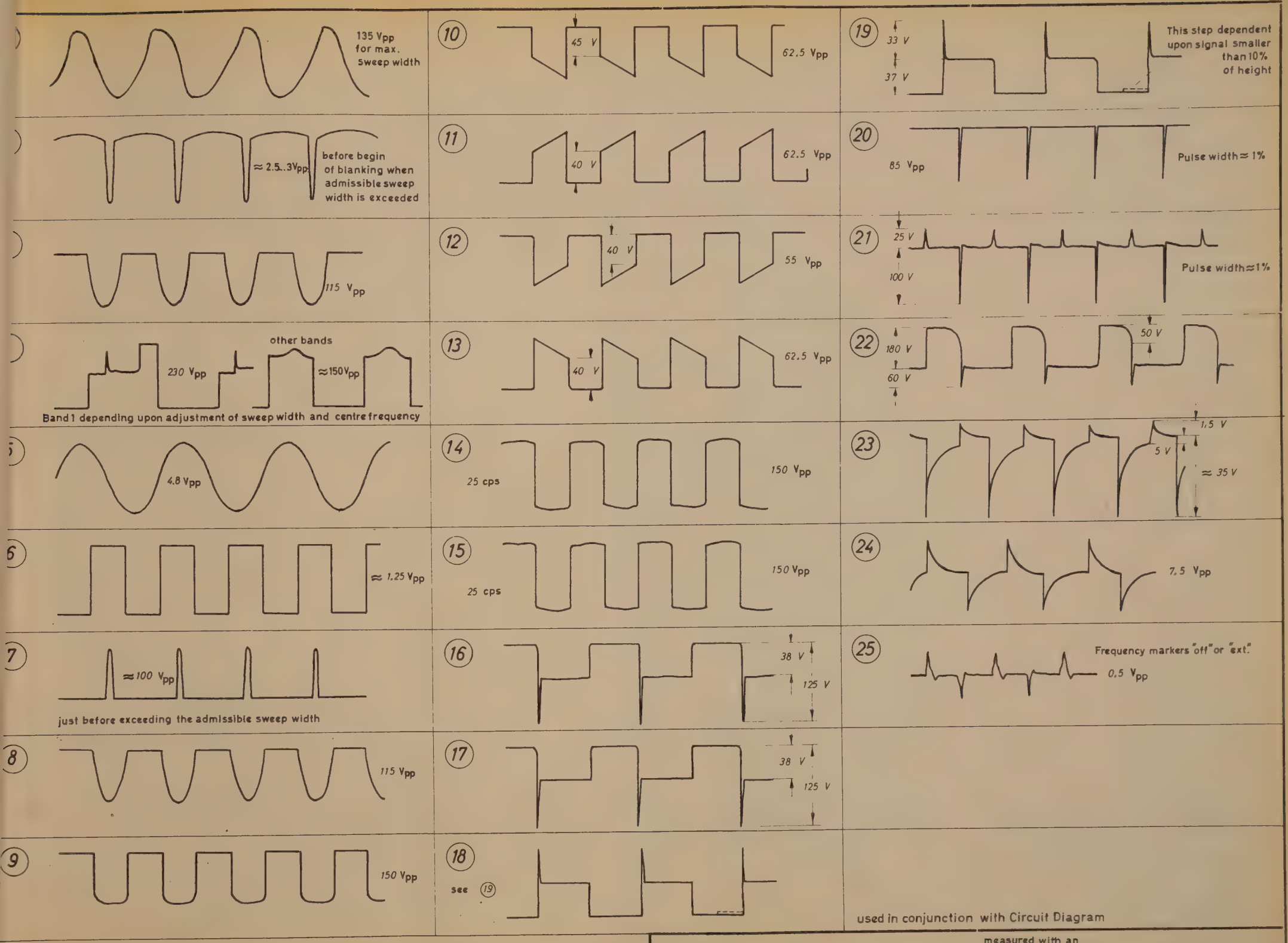

used in conjunction with Circuit Diagram

POLYSKOP - Wave form chart

measured with an R&S Wide-Band Oscilloscope Type OBF without diode probe

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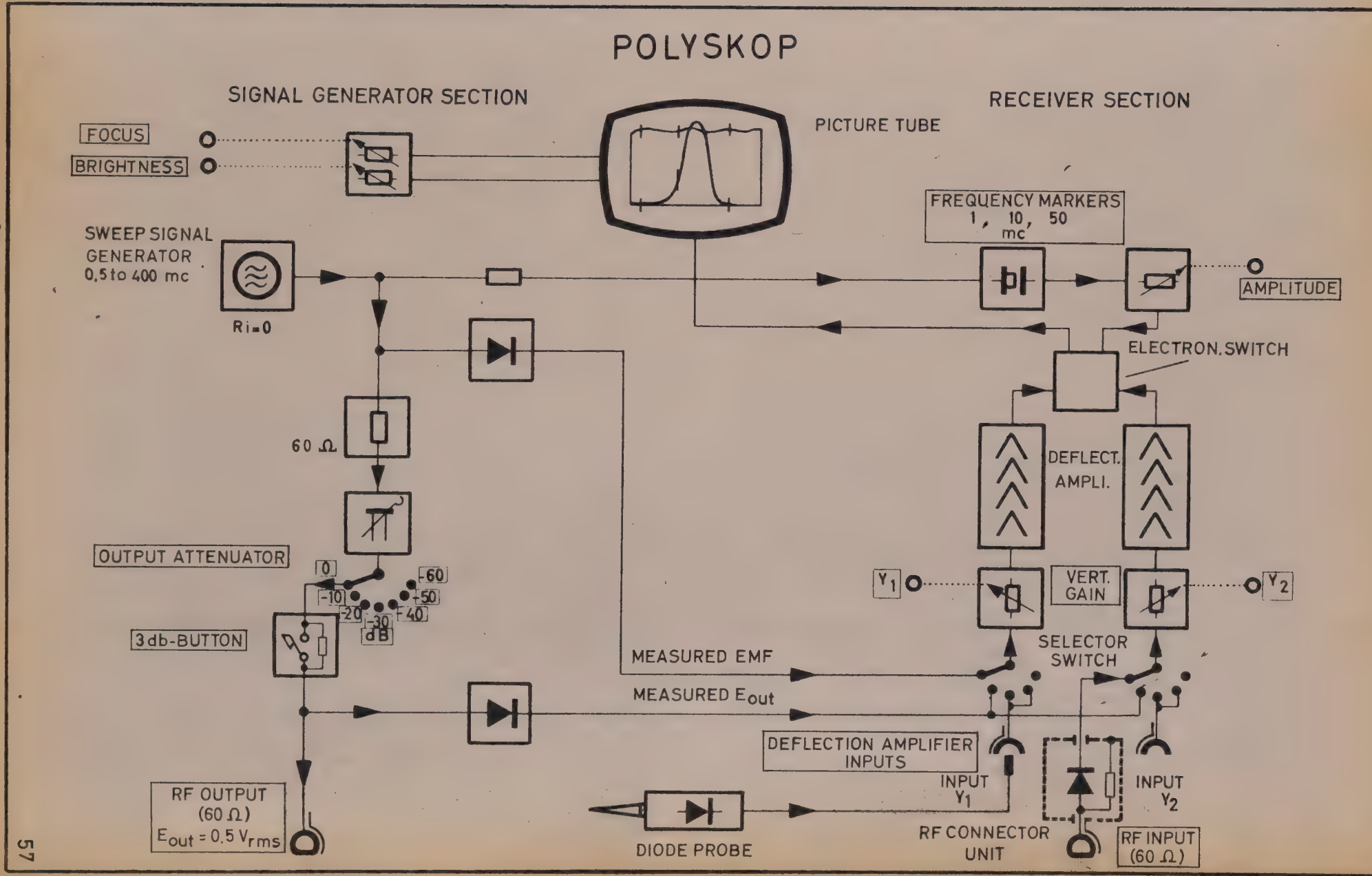

6. Specifications

6.1 Sweep Signal Generator

Frequency range	0.5 to 400 mc
in five bands	0.5-50, 50-150, 150-220, 220-310, 310-400 mc
Overlapping of the bands	more than 10 mc (5 mc between sub-ranges 1 and 2)
Sweeping	
Sweep width	±0.5 to ± 50 mc about centre frequency but not beyond band limits; continuously variable
Centre frequency	adjustable within the bands
Frequency sweep	sine wave, retrace blanked
Amplitude modulation	possible in addition to sweeping
Frequency range	50 cps to 20 kc
Modulation depth	max. 30%
Voltage requirement	approx. 70 mv/% modulation
Input impedance	150 Ω
Input	4-mm telephone jacks (rear connection) single ended
Output voltage	0.5 mv to 0.5 v_{rms} when match-terminated variable in 10-db steps; button can be pressed to add 3 db attenuation in all the steps (Z_o=50 Ω 0.4 mv to 0.4 v_{rms})
Flatness of output level of swept r-f frequency	within 0.1% per 1 mc sweep width when match-terminated. (EMF less than 0.05% per 1 mc sweep width)
Distortion	less than 5%
Source impedance	50, 60 or 75 ohms available +)
Output	R&S connector Dezifix B ++)

+) 50-Ω model . . . . . BN 4244/50
60-Ω model . . . . . BN 4244/60
75-Ω model . . . . . BN 4244/75

++) Instruments with other connectors: please enquire.

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6.2	Display Section	two identical, independent channels electronically switched at one-half the sweep frequency, gain continuously variable
	Inputs	(1) coaxial r-f input with built-in terminating resistor and detector (2) two r-f diode probes (3) two deflection amplifiers
	R-f input	50, 60 or 75 ohms +); detector isolated from d-c
	Frequency range	0.5 to 400 mc (usable to 1000 mc)
	Sensitivity	50 mv for full picture height
	Reflection	less than 3% up to 400 mc
	Power rating	max. 1 w r-f plus d-c
	Connector	R&S connector Dezifix B ++)
	R-f diode probes	
	Frequency range	0.5 to 400 mc
	Sensitivity.	30 mv for full picture height
	Voltage rating	max. 10 volts
	Input impedance at 300 mc .	20 kilohms shunted by 3 µµf; withstands d-c up to 500 volts
	Connection	to deflection amplifier input sockets (pos. signal)
	Deflection amplifier inputs .	for circuits under test which contain a detector
	Frequency range	3 cps to 7 kc
	Sensitivity	2 mv for full picture height
	Polarity	positive or negative
	Input impedance	500 kilohms; withstands d-c up to 500 volts
	Connectors	coaxial 13-mm sockets R&S No. FD 413/21; also suited for 4-mm banana plugs
6.3	Picture Tube Assembly	oscilloscope for simultaneous presentation of two quantities by electronic switching
	Size of screen	280 x 210 mm, 36-cm picture tube with magnetic deflection
	Quantities measured, separately selectable for each channel .	output voltage of sweep signal generator; voltages of circuit under test applied to r-f input or r-f diode probes inputs; EMF of sweep signal genrator, for performance check

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Frequency axis	horizontal
full width of picture	equal to sweep width of sweep signal generator
Calibration	by frequency markers
Frequency markers	internal and/or from ext. frequency; variable in amplitude; independent of circuit under test
internal	crystal-controlled; at 1 or 10 mc; 50 mc for orientation (free running), switch-selected
external	frequency of an external signal generator; voltage requirement approx. 1 v_{rms}, input: R&S connector Dezifix B ++) on the rear, 50, 60 or 75 ohms +)
Voltage axis	vertical; zero reference line can be vertically shifted over full height of screen
Voltage indication characteristic	approx. square law (r-f inputs); dependent on rectifier circuit under test at deflection amplifier inputs
Voltage reference lines . . .	provided at linear sub-divisions on replaceable illuminated plexiglass graticule
Calibration	by reduction of the sweep signal generator voltage by 3, 10, 20, etc. db
Range of attenuation and gain measurements	45 db for attenuation; 60 db for gain, extendible by attenuator pads
Accuracy	$\pm$0.1 db for 3, 10, 20, etc. db approx. $\pm$0.5 db for intermediate values

Response curves that change in amplitude from 10% to 100% of max. value within 20 kc of sweep width cannot be fully resolved.

6.4 Common Data

Power supply	115/125/220/235 v $^{+10}_{-10}$%, 48 to 61 cps (150 va)

Valves, etc.

Valves	2 x E 88 CC	1 x EL 84
	8 x 180 F	2 x EL 86
	14 x ECC 81	1 x MW 36-44
	4 x EF 804 S	1 x EAA 91
	2 x 85 A 2	
Transistors	2 x OC 604 spec.	1 x CTP 1109

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Scale lamps	2 x RL 165 S (Osram 6425; 6 v/0.5 amp) 1 x RL 163 (Osram 3341; 7 v/0.3 amp)
Fuses	2 amp for 115/125 v 1 amp for 220/235 v
Dimensions (W x H x D)	540 x 370 x 575 mm (steel cabinet with cover)
Weight, accessories included . .	approx. 55 kg

6.5 Accessories, included in the price

1 plexiglass graticule	R&S Stock No. E 415/1 - 13.11
1 power cord , 2 m	R&S Stock No. LK 333
2 r-f diode probes with 2 spare tips	R&S Stock No. E 415/1 - 18
1 cable (50, 60 or 75 ohms) with 2 R&S connectors Dezifix B	BN 900556/100 ++)

6.6 Recommended Accessories (on separate order)

Dezifix precision cable

50 Ω, approx. 35 m	BN 356812/50 ++)
60 Ω, approx. 40 m	BN 356812/60 ++)
75 Ω	please enquire

Coaxial 13-mm plugs, R&S connectors Dezifix B, adapters from Dezifix B connector to other makes, cables for 13-mm plugs, Dezifix cables, attenuator pads, matching pads for various characteristic impedances.

6.7 Order Numbers

50-Ω model	BN 4244/50
60-Ω model	BN 4244/60
75-Ω model	BN 4244/75

When instruments with other connectors are desired, please state the type accurately.

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7. Maintenance of the POLYSKOP

7.1 Picture Tube

A normal TV picture tube is used in the POLYSKOP for the display. The steel cabinet and the 5-mm plexiglass protector offer a protection against a possible damaging of the picture tube.

The picture tube must support a force of several tons of atmospheric weight. If the glass enclosure is damaged by shock, forceful impacts, or even scratches, an implosion may result that can seriously injure persons standing nearby. It is dangerous to use or set up the POLYSKOP anywhere without the steel cabinet or plexiglass protector. When cleaning the plexiglass protector or making repairs where the POLYSKOP is removed from its cabinet, face and hands should be protected with a face guard and gloves. These precautions are especially important when a new picture tube is being mounted. If the equipment must be left without a cabinet for a prolonged period, a linen cover should be placed over the set.

7.2 Replacing the Picture Tube (see Fig. 18)

The set must be shut off for at least 10 minutes so that the high voltage of 4 kv has definitely dropped. However, we recommend that the high voltage cable be disconnected and short-circuited to earth. In addition, the high voltage aquadag connector on the picture tube should be earthed with a piece of wire in order to remove any remaining charges.

When replacing the picture tube, the above mentioned precautions are to be especially observed. Without using any force, the picture tube may be removed from its socket. The ion-trap magnet located between the tube base and the focus coil is then removed by pulling back. The mounting screws are loosened which fasten the entire deflection system to the chassis. After removing the multi-pin connector, the deflection system can be removed from the rear of the set. The neck of the picture tube is then supported with a soft rag. Finally, the tension band near the face of the tube is loosened and the picture tube is removed from the top of the set. The picture tube should never be held by the neck alone or even turned. One should always carry the picture tube with its face downward in the flat of the left hand while the neck is lightly held with the right hand. The picture tube may then be set upon a

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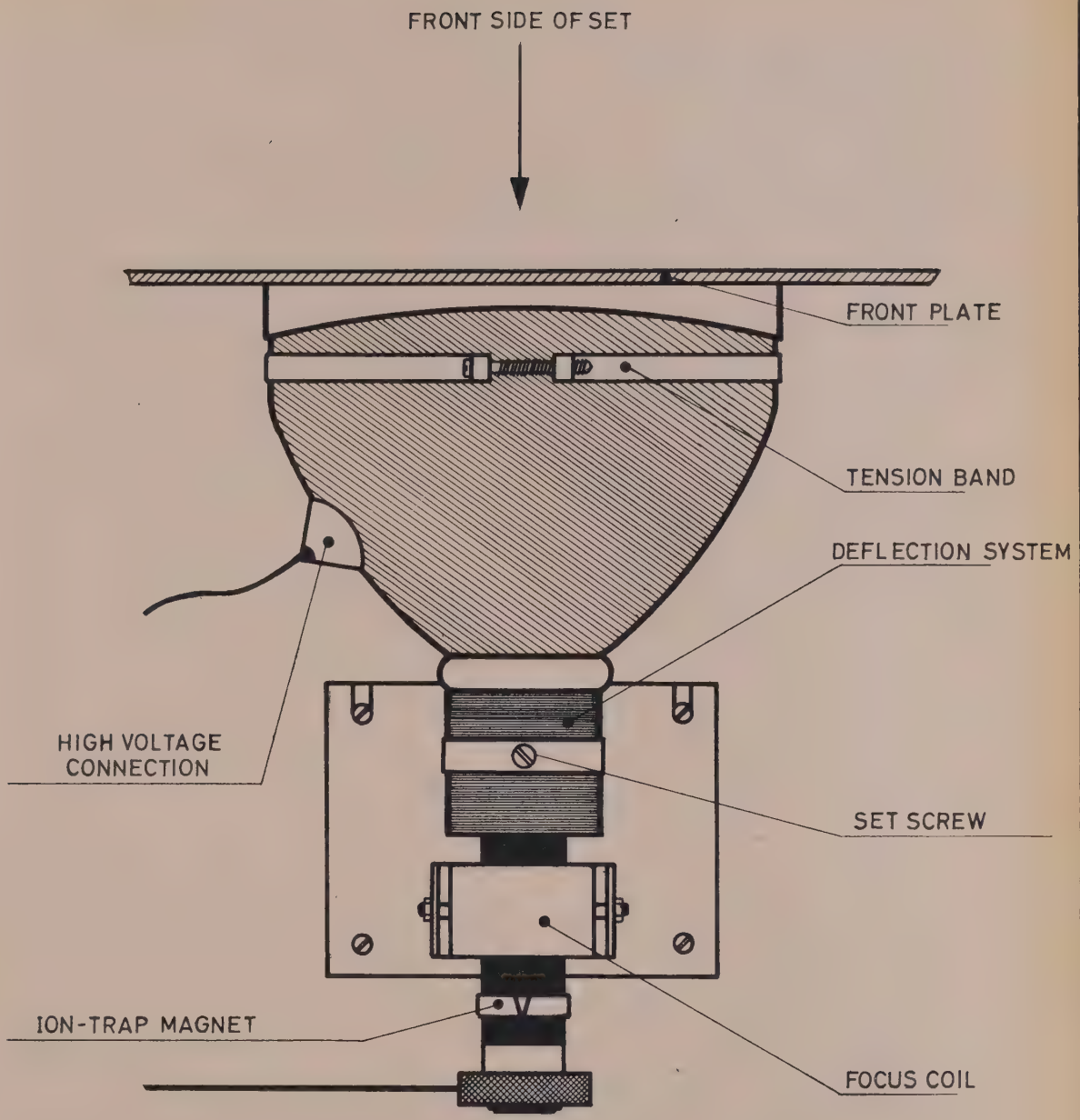

POSITION OF PICTURE TUBE

POLYSKOP

Fig.18

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soft surface and secured against tipping.

The n e w picture tube is then mounted using the reverse procedure.

7.3 Adjusting the Ion-trap Magnet

The ion-trap magnet is pushed on the tube neck so that the arrow points to the tube base (pin 9). The set is turned on and the intensity control is advanced fully clockwise. By moving the ion-trap magnet forwards and backwards in addition to turning it, an indication of the beam is obtained. The intensity control is then turned back while the ion-trap magnet is adjusted to maintain the highest intensity.

7.4 Adjusting the Display Position

An inclination of the displayed oscillogram may be corrected with the deflection coils. First loosen the screw on the holding band of the deflection coil assembly and push this assembly as far as possible in the direction toward the face of the picture tube. By rotating the deflection coils, the horizontal position is adjusted. A separate adjustment of the vertical and horizontal deflection coils is not possible and also not necessary.

7.5 Adjusting the Focus Coil

The focus coil is located between the deflection coils and the ion-trap magnet. The focus coil may be adjusted in all directions after the two screws to the chassis and the nuts on the side have been loosened. The coil is adjusted until the displayed 0-reference line is perfectly straight and the beam does not disappear from view at the edges of the screen. You should be careful that no point of the inner surface of the focus coil comes closer than 1 mm to the neck of the picture tube. In no case should the focus coil be permitted to touch it.

The focus coil and ion-trap magnet cannot be adjusted without interaction. As a last step, the ion-trap magnet must once again be adjusted for maximum intensity of the beam. The set is placed into its cabinet after a l l the loosened screws have been tightened.

7.6 Replacing the Valves in the POLYSKOP

All valves in the POLYSKOP can be replaced with the same type of replacement valves without affecting the operation of the set.

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7.7 Replacing the Transistors

The power transistor T 3 is mounted on a cooling plate located underneath the r-f output connector (3 db attenuator). Note that the cooling plate is isolated from the chassis and has approx. 12 v d-c with respect to earth. Bits of metal or screws may cause a short-circuit that can lead to the distruction of the rectifiers.

The two transistors T 1 and T 2 and the Zener or breakdown diode Gl 14 are accessible after removal of the mount for the heater voltage control, potentiometer R 258, located under the picture-tube chassis mount. The replacement transistor must be soldered in.

After replacing the transistors or the breakdown diode, a readjustment of the stabilized heater voltage is necessary (see paragraph 8.2).

7.8 Replacing the Graticule Illumination Lamps

To replace the two small tubular lamps which serve to illuminate the graticule, the plexiglass protector must be removed by pulling it out at the top. After the plexiglass protector has been removed, the two molded phenolic wedges located above the lamps in the protector guiding tracks may be tilted inward so that the lamps can be removed from the outside. To remove the lamp at the right-hand side, the screening cover which covers the vertical-deflection amplifier inputs must be removed. The a-c pilot lamp may be replaced with a normal screw-base lamp.

7.9 Replacing and Cleaning the Graticule

After the set is removed from its steel cabinet, the plexiglass protector containing the graticule may be pulled upward out of the guiding tracks. The face of the picture tube may only be cleaned with a dampened soft rag. The same is true for the plexiglass protector, which is quite easily scratched.

7.10 Pointers for Proper Operation

7.10.1 Operation from Low A-C Supply Voltage

The POLYSKOP operates perfectly from voltages that deviate from the nominal value by up to ±10%. However, a supply voltage of -10% from nominal value should be avoided for continuous operation since certain valves may fail too soon because of overloading.

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7.10.2 Overloading the Oscillator Valves

In the first range 0.5 to 50 mc, with the sweep width control turned to minimum and the centre frequency control turned to maximum, an output frequency greater than 50 mc is produced, which lies outside the limit frequency of the wide-band amplifier. The frequency is therefore no longer passed. The EMF control circuit attempts to hold the output voltage constant and feeds the maximum anode voltage to the oscillator valves used in this frequency range. In particular valve Rö 8 is overloaded and may suffer damage.

7.10.3 Preventing Overheating

Practically the entire a-c power delivered to the set is transformed into heat. The steel cabinet of the set is perforated and a blower is provided to carry away the heat. If the set is placed upon a soft surface such as felt, the underneath perforations are blocked, which prevents the cooling air from entering. The heat dissipation is also hindered when other equipment producing heat is placed upon the POLYSKOP.

8. Repairing the POLYSKOP (see Circuit Diagram and Table of Replaceable Parts at end of this section)

You are asked to obtain help from our nearest representative in case of any malfunctioning of the set. Repairs should only be made in emergencies without a factory representative. The most important procedures for making alignments are compiled in the following paragraphs.

The locations of the adjustments are shown in the sketches of Fig. 19.

8.1 Adjusting the Regulated Anode Supply Voltage

The regulated anode supply voltage is adjusted to +250 v with R 218. The voltage is measured from the cathode of valve Rö 30 or Rö 31 to earth.

8.2 Adjusting the Regulated Heater Voltage

The regulated heater voltage should have 6.3 v. It is adjusted to this value with R 258. The voltage is measured at one of the oscillator valves Rö 8 or Rö 9 after opening the left side of the chassis.

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8.3 Testing the Voltage Values

The normal voltage values are given in the circuit diagram for the most important points in the POLYSKOP circuit. These voltages should be measured with a high-impedance voltmeter such as the ROHDE & SCHWARZ Type URI or a similar type vacuum-tube voltmeter.

8.4 R-F Oscillators

The four r-f oscillators in the left-hand side of the POLYSKOP are adjusted at the factory and secured with lacquer. We emphatically recommend that no changes be made on the tiny oscillator coils which are wound on a special ferrite core. Frequency range changes cannot occur from replacing the oscillator valves.

If the lowest range 0.5 to 50 mc does not function properly, the frequency of the fixed oscillator may be adjusted with trimmer C 12. The frequency should lie around 150 mc. The output coupling loop of the oscillator (Rö 1) is pushed only close enough to the tank circuit so that the EMF indication response is flat up to 50 mc with the output attenuator set at -20 db. A coupling that is too high results in an inadmissibly high distortion which is caused by overdriving the mixing diode Gl 1.

8.5 Setting the R-F Output Voltage

The r-f output voltage of the POLYSKOP is adjusted at the factory with the control R 86 so that, with the output attenuator set at 0 db, the output voltage is 0.5 v_{rms} when connected to a resistor equal to the source resistance, i.e. with matched conditions. The adjustment is made with the help of a wide-band oscilloscope. The POLYSKOP is adjusted to a small sweep width in the lowest frequency range between 1 and 3 mc which are frequencies that can be displayed on the oscilloscope without fall-off. The display amplitude of the r-f signal should have 1.4 v_{rms}.

8.6 Replacing the Measuring Diodes

8.6.1 Control Diode

The location of the control diode Gl 12 can be seen from Fig. 19. The diode may be replaced with the same type. It is necessary to pay particular attention to the polarity. (Commercial cartridge-type diodes are available that have a reversed polarity.)

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8.6.2 E_{out} Diode

This diode is accessible only after removing the 3-db attenuator assembly. To accomplish this, the Precision Dezifix connector flange must first be unscrewed. Care must be taken that this flange is not marred. A piece of rubber or leather should be wrapped around the flange before it is gripped with pliers or a pipe wrench. The next step is to remove the screw located just to the right of the 3-db button. The 3-db attenuator assembly may then be removed and brought out to the side of the set where it is easy to work on. Now remove the screws holding the cover plate. The diode is now accessible and may be replaced. The diode must be carefully and quickly soldered. The leads should be held with long-nose pliers to provide a conducting path for the heat away from the diode. It is also advisable to remove the soldering iron from the a-c supply to remove the possibility of the diode being destroyed by an excessive voltage.

8.6.3 RF Input Connector Assembly

To replace the diode in the r-f input connector assembly, remove the cover over the assembly and unscrew the diode.

8.7 O-Reference Line Adjustment

If the O-reference line is not level or has a sag, the focus coil must be repositioned (see paragraph 8.5). If the O-reference line has a double trace, this may be corrected with potentiometer R 168.
The adjustment is made as follows:

(1) Remove valve Rö 19 (type EL 84) from its socket.
(2) Adjust the O-reference line to slightly under the lower edge of the picture screen.
(3) Now replace valve Rö 19.
(4) Adjust the O-reference line to the centre of the screen with the O-LINE control and potentiometer R 167.
(5) Adjust R 168 so that the O-reference line does not appear as a double trace.
(6) Finally, the control range of the O-LINE control is adjusted so that the O-reference line is adjustable from the lower edge of the screen up to slightly above the screen centre.

You should not leave the O-reference line in the upper part of the screen for prolonged periods because of the overloading of valve Rö 19.

; 958; 50 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

8.8 Equal Display Amplitudes for Positive or Negative Signals

The two potentiometers, R 150 for the Y_2-deflection amplifier, and R 152 for the Y_1-deflection amplifier, are provided for adjusting equal gains for positive or negative signals in the two amplifier channels. These potentiometers are accessible after the right-hand cover plate is removed. In general, any gain difference is caused by a defective valve, for instance Rö 15 or Rö 21.

8.9 Marker Generator

If the marker amplitudes are insufficient, especially in the upper frequency ranges, it may be necessary to replace the marker mixing diode Gl 12. The diode mounted in clips near valve Rö 20 is accessible after the chassis covering plate on the right-hand side is removed.

If the 1-mc or 10-mc marker spectrum drops out, the respective crystal should be checked and replaced if necessary. The two crystals are mounted in plug-in receptacles located inside of the set near Rö 26.

The 50-mc markers are produced in the tank circuit containing L 36. When the valve Rö 26 is replaced, it is possible that the 50-mc markers do not coincide exactly with the corresponding 10-mc markers. A correct marker position may again be established by adjusting the tuning slug of coil L 36. The adjustment is best carried out in the upper frequency range around 350 mc.

8.10 Adjusting the Display Width

The width of the display can be adjusted with potentiometer R 68, the adjustment being made at the nominal a-c supply voltage. The display width is adjusted to about 1 cm beyond the limits of the graticule X-co-ordinates, thereby assuring a full display width even with a low a-c supply voltage.

8.11 Adjusting the Keying Phase

The keying of the sweep oscillators must be phased correctly so that during the return trace of the display, a 0-reference line is produced. The phase position of the keying pulse can be adjusted with potentiometer R 73. The adjustment is best made with a reduced display width, the correct position of the keying pulse being especially observable.

An adjustment of the keying phase may be necessary when the POLYSKOP is used at another a-c supply frequency, i.e. different from 50 cps.

R 6194
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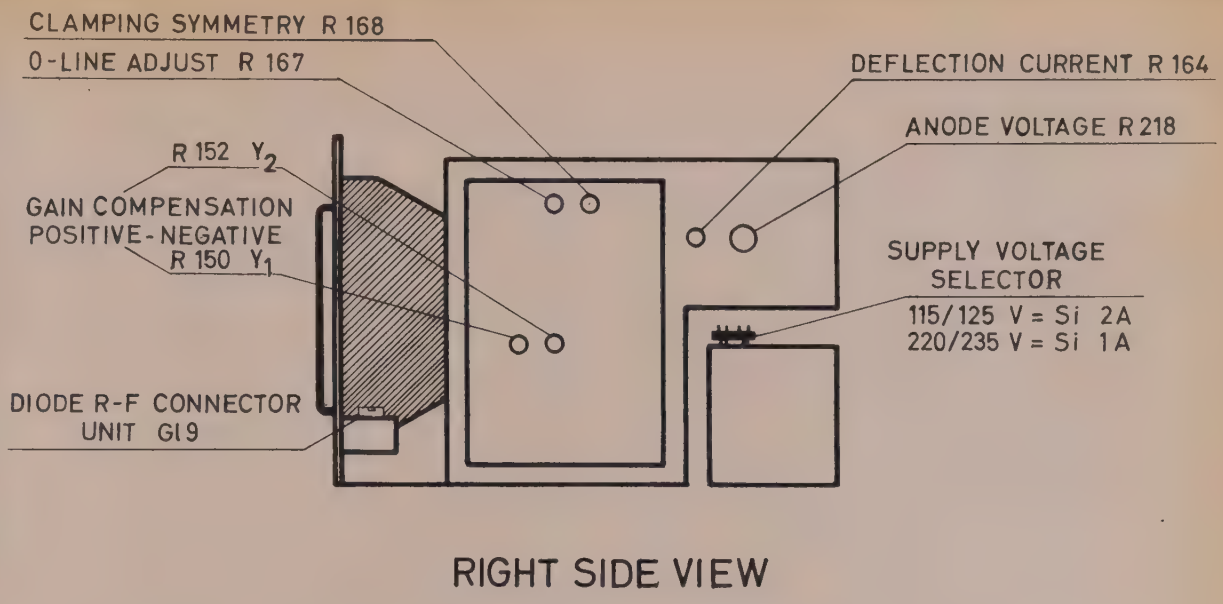
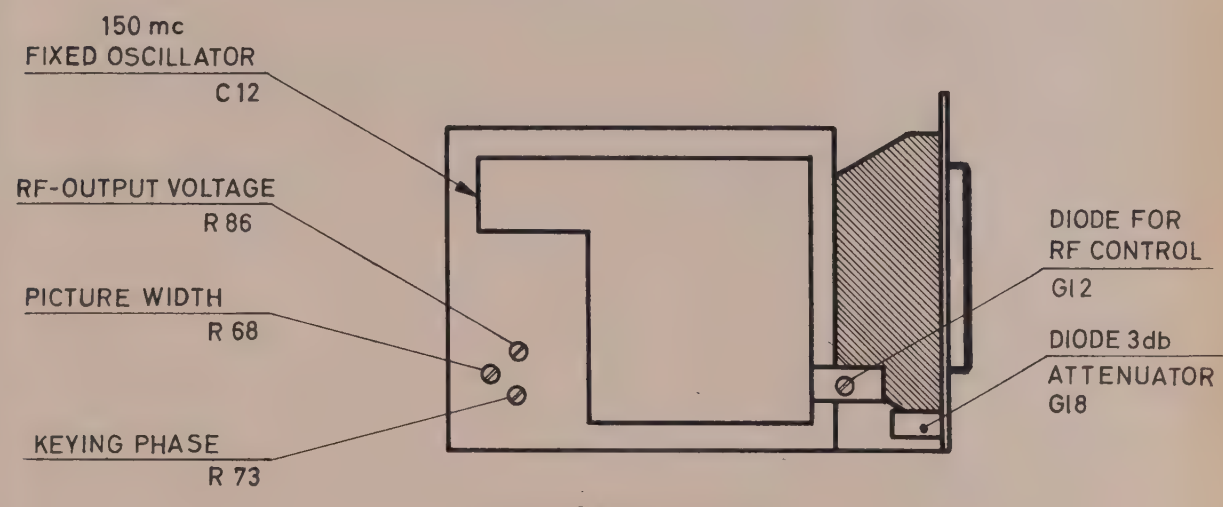
Bl. 69

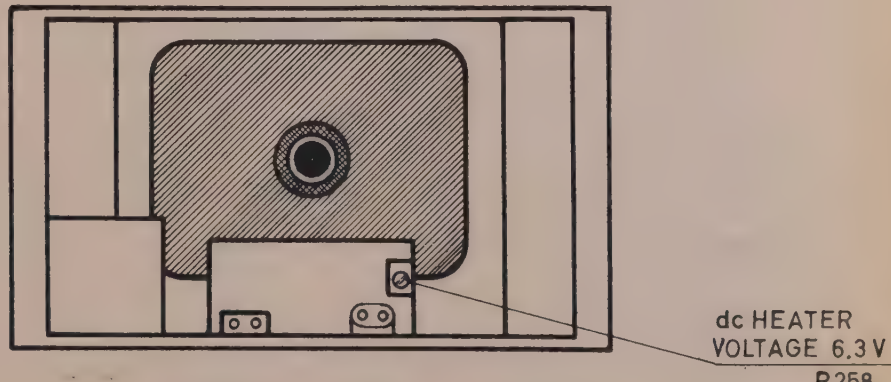
958; 50 x 100 S; ROHDE & SCHWARZ, MÜNCHEN



RIGHT SIDE VIEW



LEFT SIDE VIEW



REAR VIEW

POLYSKOP

Fig. 19

8.12 Table of Replaceable Parts

(Reference numbers according to circuit diagram)

Ref. No.	Designation	Ratings	R&S Stock No.
BA1	Stabilizer, cell		BAS 11001
BA2	Stabilizer, cell		BAS 11001
C1	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C2	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C3	Capacitor, feed-through, paper	10,000 µµf/300 v	CPD 10 000/300
C4	Capacitor, paper	10,000 µµf/250 v	CPM 10 000/250
C5	Capacitor, paper	10,000 µµf/250 v	CPM 10 000/250
C6	Capacitor, feed-through, paper	10,000 µµf/300 v	CPD 10 000/300
C7	Capacitor, paper	10,000 µµf/250 v	CPM 10 000/250
C8	Capacitor, paper	10,000 µµf/250 v	CPM 10 000/250
C9	Capacitor, paper	10,000 µµf/250 v	CPM 10 000/250
C10	Capacitor, feed-through, paper	10,000 µµf/300 v	CPD 10 000/300
C11	Capacitor, ceramic	22 µµf	CCG 68/22
C12	Trimmer	4 to 29 µµf	CV 8125
C13	Capacitor, ceramic	22 µµf	CCG 68/22
C14	Trimmer, ceramic, tubular	1 to 11 µµf	CV 7210
C15	Capacitor, ceramic	100 µµf	CCH 68/100
C16	Capacitor, ceramic	330 µµf	CCG 94/330
C17	Capacitor, ceramic	2200 µµf	CCG 94/2200
C18	Trimmer, ceramic, tubular	0.5 to 3 µµf	CV 7202
C19	Capacitor, ceramic	8 µµf	CCG 41/8

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

758; 100 x 100 S; ROHDE & SCHWARZ MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
C20	Trimmer, ceramic, tubular	0.5 to 3 µµf	CV 7202
C21	Trimmer, ceramic, tubular	0.5 to 3 µµf	CV 7202
C22	Trimmer, ceramic, tubular	0.5 to 3 µµf	CV 7202
C23	Trimmer, ceramic, tubular	0.5 to 3 µµf	CV 7202
C24	Trimmer, ceramic, tubular	0.5 to 3 µµf	CV 7202
C25	Capacitor, feed-through, paper	10,000 µµf/300 v	CPD 10 000/300
C26	Trimmer, ceramic, tubular	1 to 11 µµf	CV 7210
C27	Capacitor, ceramic	27 µµf	CCH 31/27
C28	Trimmer, ceramic, tubular	1 to 11 µµf	CV 7210
C29	Capacitor, ceramic	27 µµf	CCH 31/27
C30	Trimmer, ceramic, tubular	1 to 11 µµf	CV 7210
C31	Capacitor, ceramic	27 µµf	CCH 31/27
C32	Trimmer, ceramic, tubular	1 to 11 µµf	CV 7210
C33	Capacitor, ceramic	27 µµf	CCH 31/27
C34	Capacitor, paper	10,000 µµf/250 v	CPK 10 000/250
C35	Trimmer, ceramic, tubular	1 to 11 µµf	CV 7210
C36	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C37	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C38	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C39	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C40	Capacitor, ceramic	2 µµf	CCG 11/2
C41	Capacitor, ceramic	22 µµf	CCG 68/22
C42	Capacitor, ceramic	8 µµf	CCG 41/8
C43	Capacitor, ceramic	39 µµf	CCH 31/39
C44	Capacitor, ceramic	8 µµf	CCG 41/8
C45	Capacitor, ceramic	6 µµf	CCG 41/6

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

768; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
C46	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C47	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C48	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C49	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C50	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C51	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C52	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C53	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C54	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C55	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C56	Capacitor, bypass		E 415 - 6.3
C57	Capacitor, MP	0.5 µf/2000 v	CMR 0,5/2000/2
C58	Capacitor, MP	0.5 µf 3.2/4.8 kv	Bosch Stock No.: K03 GH 298 A
C59	Capacitor, electrolytic	100 µf/350 v	CEG 21/50 + 50/350
C60	Capacitor, electrolytic	100 µf/350 v	CEG 21/50 + 50/350
C61	Capacitor, electrolytic	100 µf/350 v	CEG 21/50 + 50/350
C62	Capacitor, electrolytic	100 µf/350 v	CEG 21/50 + 50/350
C63	Capacitor, MP	2 µf/500 v	CMR 2/500
C64	Capacitor, MP	0.5 µf/250 v	CMR 0,5/250
C65	Capacitor, paper	100,000 µµf/250 v	CPK 100 000/250
C66	Capacitor, paper	10,000 µµf/250 v	CPK 10 000/250
C67	Capacitor, electrolytic	32 µf/350 v	CEG 21/16 + 16/350
C68	Capacitor, electrolytic	32 µf/350 v	CEG 21/16 + 16/350

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

Ref. No.	Designation	Ratings	R&S Stock No.
C69	Capacitor, paper	100,000 µµf/400 v	CPK 100 000/400
C70	Capacitor, paper	100,000 µµf/250 v	CPK 100 000/250
C71	Capacitor, MP	16 µf/250 v	CMR 16/250
C72	Capacitor, feed-through, paper	10,000 µµf/300 v	CPD 10 000/300
C73	Capacitor, paper	10,000 µµf/250 v	CPM 10 000/250
C74	Capacitor, feed-through, paper	10,000 µµf/300 v	CPD 10 000/300
C75	Capacitor, bypass		E 415 - 10.10
C76	Capacitor		E 415 - 7.3
C77	Capacitor, MP	1 µf/250 v	CMR 1/250/2
C78	Capacitor, MP	1 µf/250 v	CMR 1/250
C79	Capacitor, synth. foil	2500 µµf/250 v	CKS 2500/250
C80	Capacitor, MP	1 µf/250 v	CMR 1/250
C81	Capacitor, electrolytic	10 µf/15 v	CED 21/10/15
C82	Capacitor, synth. foil	1000 µµf/1000 v	CKS 1000/1000
C83	Capacitor, MP	1 µf/250 v	CMR 1/250/1
C84	Capacitor, MP	1 µf/250 v	CMR 1/250/1
C85	Capacitor, ceramic	220 µµf	CCG 68/220
C86	Capacitor, MP	1 µf/250 v	CMR 1/250/2
C87	Capacitor, electrolytic	200 µf/350 v	CEG 21/100 + 100/350
C88	Capacitor, MP	1 µf/250 v	CMR 1/250
C89	Capacitor, synth. foil	2500 µµf/250 v	CKS 2500/250
C90	Capacitor, MP	1 µf/250 v	CMR 1/250
C91	Capacitor, ceramic	27 µµf	CCG 68/27
C92	Capacitor, feed-through, paper	10,000 µµf/300 v	CPD 10 000/300
C93	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C94	Capacitor, paper	5000 µµf/400 v	CPK 5000/400

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

'58; 100 x 100 3; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
C95	Capacitor, ceramic	100 µµf	CCH 68/100
C96	Capacitor, ceramic	100 µµf	CCH 68/100
C97	Capacitor, ceramic	220 µµf	CCH 68/220
C98	Capacitor, ceramic	220 µµf	CCH 68/220
C99	Capacitor, ceramic	100 µµf	CCH 68/100
C100	Capacitor, electrolytic	4 µf/350 v	CED 21/4/350
C101	Capacitor, electrolytic	100 µf/100 v	CED 21/100/100
C105	Capacitor, feed-through, paper	50,000 µµf/300 v	CPD 50 000/300
C106	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C107	Capacitor, feed-through, ceramic	5000 µµf/500 v	CFR 1/5000/500
C108	Capacitor, ceramic	56 µµf	CCH 31/56
C109	Capacitor, ceramic	100 µµf	CCH 68/100
C110	Capacitor, ceramic	10 µµf	CCH 41/10
C111	Capacitor, synth. foil	500 µµf/500 v	CKS 500/500
C112	Capacitor, ceramic	27 µµf	CCG 68/27
C113	Capacitor, ceramic	56 µµf	CCH 31/56
C114	Capacitor, ceramic	22 µµf	CCH 31/22
C115	Capacitor, ceramic	220 µµf	CCH 68/220
C116	Capacitor, paper	50,000 µµf/250 v	CPM 50 000/250
C117	Capacitor, feed-through, paper	50,000 µµf/300 v	CPD 50 000/300
C118	Capacitor, paper	50,000 µµf/250 v	CPM 50 000/250
C119	Capacitor, feed-through, paper	50,000 µµf/300 v	CPD 50 000/300
C120	Capacitor, bypass	2500 µµf/350 v	CBR 1/2500/350
C121	Capacitor, feed-through, paper	50,000 µµf/300 v	CPD 50 000/300
C122	Capacitor, bypass	2500 µµf/350 v	CBR 1/2500/350

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

Ref. No.	Designation	Ratings	R&S Stock No.
C123	Capacitor, feed-through, paper	50,000 µµf/300 v	CPD 50 000/300
C124	Capacitor, synth. foil	1000 µµf/500 v	CKS 1000/500
C125	Capacitor, ceramic	10 µµf	CCG 41/10
C128	Capacitor, ceramic	10 µµf	CCG 68/10
C129	Capacitor, paper	1000 µµf/1000 v	CPK 1000/1000
C130	Capacitor, synth. foil	10,000 µµf/250 v	CKS 10 000/250
C131	Capacitor, ceramic	10 µµf	CCG 68/10
C132	Capacitor, ceramic	27 µµf	CCG 68/27
C133	Capacitor, ceramic	100 µµf	CCH 68/100
C134	Capacitor, ceramic	100 µµf	CCH 68/100
C135	Capacitor, electrolytic	2500 µf/35 v	CEE 21/2500/35
C136	Capacitor, synth. foil	2000 µµf/125 v	CKD 2/2000/125
G11	Diode, germanium		2 x GK 2501
G12	Diode, germanium		GK 2413
G13	Rectifier, HT		GNE 27/2000/1,5 D
G14	Rectifier, power		2 x GN 19/720/100 M
G15	Rectifier, power		GN 19/720/100 M
G16	Rectifier, power		GNE 14/250/40 M
G17	Diode, silicon		GK/S 35
G18	Diode, germanium		GK 2401
G19	Diode, germanium		GK 2413
G110	Diode, germanium		GK 2281
G111	Diode, germanium		GK 2281
G112	Diode, germanium		GK 2413
G113	Rectifier, power		GNB 11/30/2000 B
G114	Diode, Zener		GK/OA 126/4

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

Ref. No.	Designation	Ratings	R&S Stock. No.
L1	Coil		BV 105 745
L2	Coil		BV 105 746
L3	Coil		BV 105 747
L4	Coil		BV 105 748
L5	Coil		BV 105 748
L6	Coil		BV 105 748
L7	Coil		BV 105 748
L8	Coil		BV 105 748
L9	Coil		BV 105 749
L10	Coil		BV 105 749
L11	Coil		BV 105 749
L12	Coil		BV 105 749
L13	Coil		BV 105 749
L14	Coil		BV 105 749
L15	Choke, r-f		BV 104 735
L16	Choke, r-f		BV 104 715
L17	Coil		BV 100 743
L18	Coil		BV 105 750
L19	Coil		BV 105 750
L20	Coil		BV 104 701
L21	Coil		BV 104 701
L22	Coil		BV 100 743
L23	Coil		BV 100 743
L24	Coil		BV 112 317
L25	Coil		BV 112 318
L26	Coil		BV 100 743
L27	Choke, r-f		BV 104 735
L28	Choke, r-f		BV 104 735

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

768; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
L29	Choke, filter		DB 125/2
L30	Choke, filter		DB 125/2
L31	Coil, horiz. defl.		
L32	Coil, vert. defl.		
L33	Coil, focusing		BV 105 970
L34	Coil		BV 104 709
L35	Coil		BV 104 706
L36	Coil		BV 104 704
L37	Coil		BV 104 708
L38	Coil		BV 104 707
L39	Choke, r-f		BV 104 735
L40	Choke, r-f		BV 104 735
L41	Choke, r-f		BV 104 715
L42	Choke		BV 112 350
M1	Motor, blower		ZAM 17 001 with vanes ZV 220/10 - 1
Q1	Crystal	10 mc $\pm 2 \cdot 10^{-5}$	
Q2	Crystal	1 mc $\pm 2 \cdot 10^{-5}$	
R1	Resistor, depos. carbon	5 kΩ/0.5 w	WF 5 k/0,5
R2	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R3	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R4	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R5	Resistor, depos. carbon	10 Ω/0.05 w	WFA 10/0,05
R6	Resistor, depos. carbon	100 Ω/0.25 w	WF 100/0,25
R7	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

Ref. No.	Designation	Ratings	R&S Stock No.
R8	Resistor, depos. carbon	600 Ω/0.25 w	WF 600/0,25
R9	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R10	Resistor, depos. carbon	250 Ω/0.25 w	WF 250/0,25
R11	Resistor, depos. carbon	10 Ω/0.05 w	WFA 10/0,05
R12	Resistor, depos. carbon	600 Ω/0.25 w	WF 600/0,25
R13	Resistor, depos. carbon	10 kΩ/0.25 w	WF 10 k/0,25
R14	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R15	Resistor, depos. carbon	1.25 kΩ/0.25 w	WF 1,25 k/0,25
R16	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R17	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5
R18	Resistor, depos. carbon	16 kΩ/0.25 w	WF 16 k/0,25
R19	Resistor, depos. carbon	250 kΩ/0.5 w	WF 250 k/0,5
R20	Resistor, depos. carbon	10 Ω/0.05 w	WFA 10/0,05
R21	Resistor, depos. carbon	600 Ω/0.25 w	WF 600/0,25
R22	Resistor, depos. carbon	10 Ω/0.05 w	WFA 10/0,05
R23	Resistor, depos. carbon	600 Ω/0.25 w	WF 600/0,25
R24	Resistor, depos. carbon	10 Ω/0.05 w	WFA 10/0,05
R25	Resistor, depos. carbon	600 Ω/0.25 w	WF 600/0,25
R26	Resistor, depos. carbon	10 Ω/0.05 w	WFA 10/0,05
R27	Resistor, depos. carbon	600 Ω/0.25 w	WF 600/0,25
R28	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R29	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R30	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R31	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R32	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R33	Resistor, depos. carbon	60 Ω/0.25 w	WF 60/0,25
R34	Resistor, depos. carbon	60 Ω/0.25 w	WF 60/0,25
R35	Resistor, depos. carbon	5 Ω/0.05 w	WF 5/0,05

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

Ref. No.	Designation	Ratings	R&S Stock No.
R36	Resistor, depos. carbon	5 Ω/0.05 w	WF 5/0,05
R37	Resistor, depos. carbon	5 Ω/0.05 w	WF 5/0,05
R38	Resistor, depos. carbon	5 Ω/0.05 w	WF 5/0,05
R39	Resistor, depos. carbon	160 Ω/0.05 w	WFA 160/0,05
R40	Resistor, depos. carbon	160 Ω/0.05 w	WFA 160/0,05
R41	Resistor, depos. carbon	10 kΩ/0.25 w	WF 10 k/0,25
R42	Resistor, depos. carbon	5 kΩ/0.5 w	WFO 5 k/0,5
R43	Resistor, depos. carbon	5 kΩ/0.5 w	WFO 5 k/0,5
R44	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R45	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R46	Resistor, depos. carbon	125 Ω/0.25 w	WF 125/0,25
R47	Resistor, depos. carbon	2.5 kΩ/0.5 w	WFO 2,5 k/0,5
R48	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R49	Resistor, depos. carbon	12.5 kΩ/0.1 w	WFA 12,5 k/0,1
R50	Resistor, depos. carbon	2 kΩ/0.5 w	WFO 2 k/0,5
R51	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R52	Resistor, depos. carbon	60 Ω ±0.5 %/1 w	WFK 611/60/0,5/1
R53	Resistor, depos. carbon	25 kΩ/0.25 w	WF 25 k/0,25
R54	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R55	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R56	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R57	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R58	Resistor, depos. carbon	100 Ω/0.25 w	WF 100/0,25
R59	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R60	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R61	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R62	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R63	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

Ref. No.	Designation	Ratings	R&S Stock No.
R64	Resistor, depos. carbon	10 kΩ/0.5 w	WF 10 k/0,5
R65	Resistor, depos. carbon	6 MΩ/0.5 w	WF 6 M/0,5
R66	Resistor, depos. carbon	6 MΩ/0.5 w	WF 6 M/0,5
R67	Resistor, wire-wound	3 kΩ/12 w	WV 12/3 k
R68	Resistor, wire-wound, variable	100 Ω lin.	WR 1102/100
R69	Resistor, wire-wound, variable	10 kΩ/10 w	WR 10/10 k
R70	Resistor, wire-wound, variable	10 kΩ/10 w	WR 10/10 k
R71	Resistor, depos. carbon	5 kΩ/2 w	WF 5 k/2
R72	Resistor, depos. carbon	8 kΩ/1 w	WF 8 k/1
R73	Resistor, depos. carbon, variable	10 kΩ lin.	WS 7122 F/10 k
R74	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R75	Resistor, depos. carbon	1.25 MΩ/0.25 w	WF 1,25 M/0,25
R76	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R77	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R78	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R79	Resistor, depos. carbon	300 kΩ/0.25 w	WF 300 k/0,25
R80	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R81	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R82	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R83	Resistor, depos. carbon	500 kΩ/0.5 w	WF 500 k/0,5
R84	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R85	Resistor, depos. carbon	500 kΩ/0.5 w	WF 500 k/0,5
R86	Resistor, depos. carbon variable	250 kΩ lin.	WS 7122 F/250 k
R87	Resistor, depos. carbon	10 kΩ/0.25 w	WF 10 k/0,25
R88	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

1442; 758; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
R89	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R90	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R91	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R92	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R93	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R94	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R95	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R96	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R97	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R98	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R99	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R100	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R101	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R102	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R103	Resistor, depos. carbon	115 Ω ±1 %/0.05 w	WFS 5/115/1/0,05
R104	Resistor, depos. carbon	85.3 Ω ±1 %/0.05 w	WFS 5/85,3/1/0,05
R105	Resistor, depos. carbon	85.3 Ω ±1 %/0.05 w	WFS 5/85,3/1/0,05
R106	Resistor, depos. carbon	85.3 Ω ±1 %/0.05 w	WFS 5/85,3/1/0,05
R107	Resistor, depos. carbon	85.3 Ω ±1 %/0.05 w	WFS 5/85,3/1/0,05
R108	Resistor, depos. carbon	85.3 Ω ±1 %/0.05 w	WFS 5/85,3/1/0,05
R109	Resistor, depos. carbon	85.3 Ω ±1 %/0.05 w	WFS 5/85,3/1/0,05
R110	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R111	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R112	Resistor, depos. carbon	21.1 Ω ±1 %/0.05 w	WF 21,1/1/0,05
R113	Resistor, depos. carbon	351 Ω ±1 %/0.05 w	WF 351/1/0,05
R114	Resistor, depos. carbon	351 Ω ±1 %/0.05 w	WF 351/1/0,05
R115	Resistor, depos. carbon	400 kΩ/0.25 w	WF 400 k/0,25
R116	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

Ref. No.	Designation	Ratings	R&S Stock No.
R117	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5
R118	Resistor, depos. carbon	30 Ω/0.5 w	WF 30/0,5
R119	Resistor, depos. carbon	100 kΩ/0.05 w	WFA 100 k/0,05
R120	Resistor, depos. carbon	60 Ω ±0.5 %/1 w	WFK 611/60/0,5/1
R121	Resistor, depos. carbon, variable	500 kΩ log.	WS 7226/500 k
R122	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R123	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R124	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5
R125	Resistor, depos. carbon	125 kΩ/0.5 w	WF 125 k/0,5
R126	Resistor, depos. carbon	1.25 MΩ/0.25 w	WF 1,25 M/0,25
R127	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R128	Resistor, depos. carbon	10 MΩ/0.25 w	WF 10 M/0,25
R129	Resistor, depos. carbon	5 kΩ/0.25 w	WF 5 k/0,25
R130	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R131	Resistor, depos. carbon	60 kΩ/0.5 w	WF 60 k/0,5
R132	Resistor, depos. carbon	250 kΩ/0.5 w	WF 250 k/0,5
R133	Resistor, depos. carbon	5 kΩ/0.5 w	WF 5 k/0,5
R134	Resistor, depos. carbon	20 kΩ/0.25 w	WF 20 k/0,25
R135	Resistor, depos. carbon	1.6 MΩ/0.25 w	WF 1,6 M/0,25
R136	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R137	Resistor, depos. carbon	2.5 MΩ/0.5 w	WF 2,5 M/0,5
R138	Resistor, depos. carbon	25 kΩ/0.5 w	WF 25 k/0,5
R139	Resistor, depos. carbon	4 kΩ/0.5 w	WF 4 k/0,5
R140	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R141	Resistor, wire-wound, variable	50 Ω/4 w	WR 4/50
R142	Resistor, depos. carbon	40 kΩ/0.25 w	WF 40 k/0,25
R143	Resistor, depos. carbon	125 Ω/0.25 w	WF 125/0,25

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Ref. No.	Designation	Ratings	R&S Stock No.
R144	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R145	Resistor, depos. carbon	125 kΩ/0.5 w	WF 125 k/0,5
R147	Resistor, depos. carbon	60 Ω/0.25 w	WF 60/0,25
R149	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R150	Resistor, depos. carbon, variable	10 kΩ lin.	WS 9122 F/10 k
R151	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R152	Resistor, depos. carbon	10 kΩ lin.	WS 9122 F/10 k
R153	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R154	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R155	Resistor, depos. carbon	125 kΩ/0.5 w	WF 125 k/0,5
R156	Resistor, depos. carbon	30 kΩ/0.5 w	WF 30 k/0,5
R157	Resistor, depos. carbon	3 kΩ/0.25 w	WF 3 k/0,25
R158	Resistor, depos. carbon	600 kΩ/0.5 w	WF 600 k/0,5
R159	Resistor, depos. carbon	250 kΩ/0.5 w	WF 250 k/0,5
R160	Resistor, depos. carbon, variable	250 kΩ lin.	WS 7126/250 k
R161	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R162	Resistor, depos. carbon	200 Ω/0.5 w	WF 200/0,5
R163	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R164	Resistor, wire-wound	10 kΩ lin.	WR 10 F/10 k
R165	Resistor, depos. carbon	800 kΩ/0.25 w	WF 800 k/0,25
R166	Resistor, depos. carbon	250 kΩ/0.5 w	WF 250 k/0,5
R167	Resistor, depos. carbon, variable	50 kΩ lin.	WS 7122 F/50 k
R168	Resistor, depos. carbon, variable	50 kΩ lin.	WS 7122 F/50 k
R169	Resistor, depos. carbon, variable	500 kΩ log.	WS 7226/500 k
R170	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R171	Resistor, depos. carbon	200 kΩ/0.5 w	WF 200 k/0,5

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Ref. No.	Designation	Ratings	R&S Stock No.
R172	Resistor, depos. carbon	125 kΩ/0.5 w	WF 125 k/0,5
R173	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R174	Resistor, depos. carbon	1.25 MΩ/0.25 w	WF 1,25 M/0,25
R175	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R176	Resistor, depos. carbon	10 M/0.25 w	WF 10 M/0,25
R177	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R178	Resistor, depos. carbon	60 kΩ/0.5 w	WF 60 k/0,5
R179	Resistor, depos. carbon	250 kΩ/0.5 w	WF 250 k/0,5
R180	Resistor, depos. carbon	5 kΩ/0.5 w	WF 5 k/0,5
R181	Resistor, depos. carbon	20 kΩ/0.25 w	WF 20 k/0,25
R182	Resistor, depos. carbon	1.6 MΩ/0.25 w	WF 1,6 M/0,25
R183	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R184	Resistor, depos. carbon	2.5 MΩ/0.5 w	WF 2,5 M/0,5
R185	Resistor, depos. carbon	25 Ω/0.25 w	WF 25/0,25
R186	Resistor, depos. carbon	4 kΩ/0.5 w	WF 4 k/0,5
R187	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R188	Resistor, depos. carbon	160 kΩ/0.5 w	WF 160 k/0,5
R189	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R190	Resistor, depos. carbon	40 kΩ/0.25 w	WF 40 k/0,25
R191	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R192	Resistor, depos. carbon	10 kΩ/0.5 w	WF 10 k/0,5
R193	Resistor, depos. carbon	10 kΩ/0.5 w	WF 10 k/0,5
R194	Resistor, depos. carbon	500 kΩ/0.5 w	WF 500 k/0,5
R195	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R196	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R197	Resistor, depos. carbon	800 kΩ/0.25 w	WF 800 k/0,25
R198	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R199	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

192; 768; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
R200	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25
R201	Resistor, depos. carbon	600 kΩ/0.25 w	WF 600 k/0,25
R202	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R203	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R204	Resistor, depos. carbon	600 kΩ/0.25 w	WF 600 k/0,25
R205	Resistor, depos. carbon	400 kΩ/0.25 w	WF 400 k/0,25
R206	Resistor, depos. carbon	1.25 MΩ/0.25 w	WF 1,25 M/0,25
R207	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R208	Resistor, depos. carbon	10 kΩ/0.5 w	WF 10 k/0,5
R209	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R210	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R211	Resistor, depos. carbon	500 kΩ/0.5 w	WF 500 k/0,5
R212	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R213	Resistor, depos. carbon	30 Ω/0.25 w	WF 30/0,25
R214	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R215	Resistor, depos. carbon	1 kΩ/0.1 w	WFA 1 k/0,1
R216	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R217	Resistor, depos. carbon	100 kΩ/0.5 w	WF 100 k/0,5
R218	Resistor, depos. carbon, variable	25 kΩ lin.	WS 7122 F/25 k
R219	Resistor, depos. carbon	50 kΩ/0.5 w	WF 50 k/0,5
R220	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R221	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R222	Resistor, wire-wound	10 kΩ/10 w	WR 10/10 k
R223	Resistor, depos. carbon	160 kΩ/0.5 w	WF 160 k/0,5
R224	Resistor, depos. carbon, variable	50 kΩ	WSD 19
R225	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R226	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

442; 758; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
R227	Resistor, depos. carbon	40 kΩ/0.5 w	WF 40 k/0,5
R228	Resistor, depos. carbon	1 kΩ/0.25 w	WF 1 k/0,25
R229	Resistor, depos. carbon	500 kΩ/0.5 w	WF 500 k/0,5
R230	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R231	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R232	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R233	Resistor, depos. carbon	50 kΩ/0.25 w	WF 50 k/0,25
R234	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R235	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R236	Resistor, depos. carbon	20 kΩ/0.5 w	WF 20 k/0,5
R237	Resistor, depos. carbon	500 Ω/0.25 w	WF 500/0,25
R238	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R239	Resistor, depos. carbon	200 Ω/0.25 w	WF 200/0,25
R240	Resistor, depos. carbon	60 Ω/0.25 w	WF 60/0,25
R241	Resistor, depos. carbon	60 kΩ/0.5 w	WF 60 k/0,5
R242	Resistor, depos. carbon	100 Ω/0.25 w	WF 100/0,25
R243	Resistor, depos. carbon	50 kΩ/0.1 w	WFA 50 k/0,1
R245	Resistor, depos. carbon	2 MΩ/0.25 w	WF 2 M/0,25
R246	Resistor, depos. carbon	2.5 kΩ/0.25 w	WF 2,5 k/0,25
R247	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R248	Resistor, depos. carbon	100 kΩ/0.25 w	WF 100 k/0,25
R249	Resistor, depos. carbon	300 kΩ/0.25 w	WF 300 k/0,25
R250	Resistor, depos. carbon	200 kΩ/0.25 w	WF 200 k/0,25
R251	Resistor, depos. carbon	500 kΩ/0.25 w	WF 500 k/0,25
R252	Resistor, depos. carbon	1 MΩ/0.25 w	WF 1 M/0,25
R253	Resistor, depos. carbon	500 kΩ/0.5 w	WF 500 k/0,5
R254	Resistor, depos. carbon, variable	25 kΩ lin.	WS 7126/25 k
R255	Resistor, depos. carbon	300 Ω/0.5 w	WFO 300/0,5

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

...42; 768; 100 x 100 3; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
R256	Resistor, depos. carbon	800 Ω/0.5 w	WFO 800/0,5
R257	Resistor, depos. carbon	10 kΩ/0.5 w	WFO 10 k/0,5
R258	Resistor, wire-wound, variable	100 Ω lin.	WR 4 F/100
RL3	Lamp, pilot	7 v/0.1 amp	
Si1	Fuse	1 amp	1 C DIN 41571
RL1	Lamp, dial	6 v/0.3 amp	RL 165 S
RL2	Lamp, dial	6 v/0.3 amp	RL 165 S
RLS1	Relay		RSS 130 042
RLS2	Relay		RSS 130 042
RLS3	Relay		RSS 130 042
RLS4	Relay		RSS 130 042
RLS5	Relay		RSS 130 042
RLS6	Relay		RSS 130 042
RLS7	Relay		RSS 130 042
RLS8	Relay		RSS 130 042
Rö1	Duo-Triode		ECC 81
Rö2	Pentode, wideband		E 180 F
Rö3	Pentode, wideband		E 180 F
Rö4	Pentode, wideband		E 180 F
Rö5	Pentode, wideband		E 180 F
Rö6	Pentode, wideband		E 180 F
Rö7	Pentode, wideband		E 180 F
Rö8	Duo-Triode		E 88 CC

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

12; 758; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
Rö9	Duo-Triode		E 88 CC
Rö10	Duo-Triode		ECC 81
Rö11	Duo-Triode		ECC 81
Rö12	Pentode		EF 804 S
Rö13	Picture tube		MW 36 - 44
Rö14	Pentode		EF 804 S
Rö15	Duo-Triode		ECC 81
Rö16	Duo-Triode		ECC 81
Rö17	Duo-Diode		EAA 91 or EB 91 (optional)
Rö18	Duo-Triode		ECC 81
Rö19	Pentode, output		EL 84
Rö20	Pentode		EF 804 S
Rö21	Duo-Triode		ECC 81
Rö22	Duo-Triode		ECC 81
Rö23	Duo-Triode		ECC 81
Rö24	Duo-Triode		ECC 81
Rö25	Duo-Triode		ECC 81
Rö26	Duo-Triode		ECC 81
Rö27	Pentode, wideband		E 180 F
Rö28	Pentode, wideband		E 180 F
Rö29	Duo-Triode		ECC 81
Rö30	Pentode, output		EL 86
Rö31	Pentode, output		EL 86
Rö32	Pentode		EF 804 S
Rö33	Reference tube		85 A 2
Rö34	Reference tube		85 A 2

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

42; 758; 100 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

Ref. No.	Designation	Ratings	R&S Stock No.
S1	Button		E 415/1 - 10
S2	Attenuator		SRS 1/12
S3	Switch		SRW 14320
S4	Switch		SRW 14220
S5	Switch		SRW 14220
S6	Switch		SRW 14220
S7	Switch, power		incl. in WSD 19
Tr1	Transformer, power		BV 104 501
Tr2	Transformer		BV 104 523
T1	Transistor		GT/OC 604 spec.
T2	Transistor		GT/OC 604 spec.
T3	Transistor		GT/CTP 1109

Diese Zeichnung ist unser Eigentum. Vervielfältigung, unbefugte Verwertung, Mitteilung an andere ist strafbar und schadenersatzpflichtig.

2; 788; 100 x 100 3; ROHDE & SCHWARZ, MÜNCHEN

9. The Fundamentals of the Sweep Frequency Method with its Limitations

9.1 Introduction

There are several important things that must be taken into account in regard to transient response if the frequency response of any four-terminal network is measured not at fixed frequencies, but with a steadily changing frequency sweeping through the desired frequency range.

The simplest example for explanation is the response of a resonant circuit connected in the anode circuit of a pentode. If this resonant circuit is suddenly excited at its resonance frequency f_o, the voltage across the circuit rises exponentially and reaches 100% of its final value after a definite time. The length of time taken to reach its final value is dependent upon the Q of the circuit and therefore its bandwidth. The greater the Q, the slower is the voltage rise across the circuit. Fig. 20 shows the response rise of such a resonant circuit.

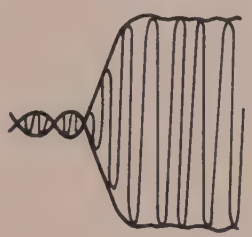

Fig. 20

The transient response time τ of a resonant circuit is calculated from

$$\tau = \frac{1}{B} \qquad \text{(sec)} \qquad (1)$$

where B is the 3-db bandwidth of the circuit. After the time τ, the voltage amplitude across the circuit has risen to over 95% of its final value (Fig. 21).

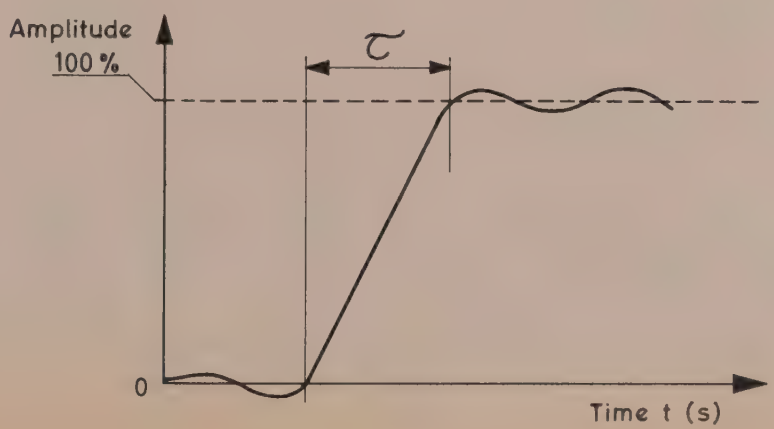

Fig. 21

098; 958; 50 x 100 S; ROHDE & SCHWARZ, MÜNCHEN

If we want to measure the voltage amplitude of the resonant circuit without appreciable error, we must allow a time of at least τ so that the circuit can reach its full amplitude.

Now if we measure the same resonant circuit with a continuously changing frequency, the exciting frequency dwells only a short time in the bandwidth of the resonant circuit depending upon the sweep width and sweep time. This "dwell time" T_v must logically be at least equal to the time constant τ so that the resonant circuit may reach its full voltage amplitude.

$$T_v \geq \tau \quad \text{(sec)} \qquad (2)$$

With periodic frequency sweeping, the ratio between the sweep width F and the bandwidth of the test item B is equal to the ratio between the sweep time T and the dwell time T_v. We may write

$$\frac{F}{B} = \frac{T}{T_v} \qquad (3)$$

Substituting $T_v = \tau$ and $\tau = 1/B$ (equation 1) in equation 3, we obtain the important relationship

$$B = \sqrt{\frac{F}{T}} \quad \text{(cps)} \qquad (4)$$

B = 3-db bandwidth of the resonant circuit
F = sweep width
T = sweep time

Using these relationships, the resulting error is less than 5% only in the case of s i m p l e single resonant circuits.

If the test item is a band-pass filter with a bandwidth B, the transient response τ is the same as for a single resonant circuit as described by

$$\tau = \frac{1}{B} \qquad ((1))$$

If we use the relationship (4) as a basis for measurement, it is true that the amplitude of the transient response will reach over 95% of its maximum value, but the response curve would have an appearance just as if a single resonant circuit were being measured (Fig. 22).

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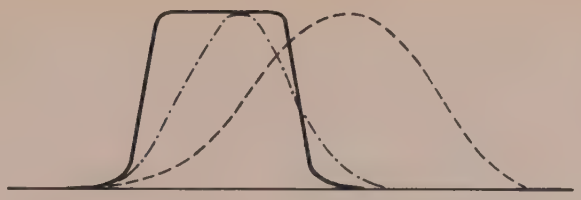

Fig. 22

The steep slopes of the band-pass curve are not resolved. Since we want to resolve the response curve of a test item as highly as possible the dwell time T_v must be so dimensioned that it is sufficiently long for the sharpest amplitude changes (Fig. 23).

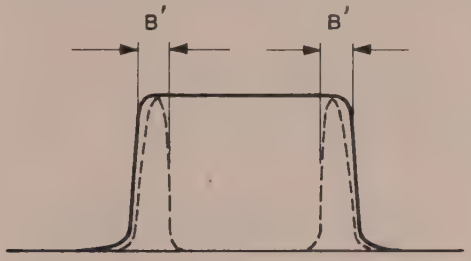

Fig. 23

If we think of the steepest slope as being one of the two slopes of a symmetrical response curve of a single-tuned circuit, the sweep rate F/T must be chosen to correspond with the bandwidth B' of this single-tuned circuit. We therefore obtain:

$$B' = \sqrt{\frac{F}{T}} \qquad \text{(cps)} \qquad (5)$$

9.2 Sine-wave Frequency Sweep

The above analysis is made on the assumption that the sweep frequency varies strictly linearly with time (constant sweep rate). Many sweep generators are swept with a sine-wave voltage obtained from the a-c supply, for instance. In this case, the sweep rate varies throughout the sweep cycle (Fig. 24).

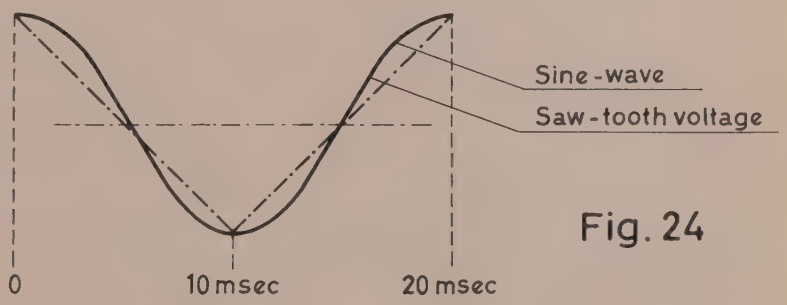

Fig. 24

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We are interested in the fastest frequency change in the sine-wave cycle. The fastest change occurs as the voltage cycle passes through zero and has a value $\pi/2 = 1.57$ times greater than a saw-tooth voltage having a period equal to a half sine-wave period. For sine-wave sweeps, the following equation should be used in place of equation (4):

$$B = \sqrt{\frac{1.57 \cdot F}{T}} \qquad (6)$$

We must always keep in mind that the resolution of the displayed response curve corresponding to equation (6) is only true at the centre of the display screen. The resolution is greater at the edges of the screen. The points A and A_1 in Fig. 25 have the same resolution as would be given by a linear saw-tooth sweep. (Fig. 25)

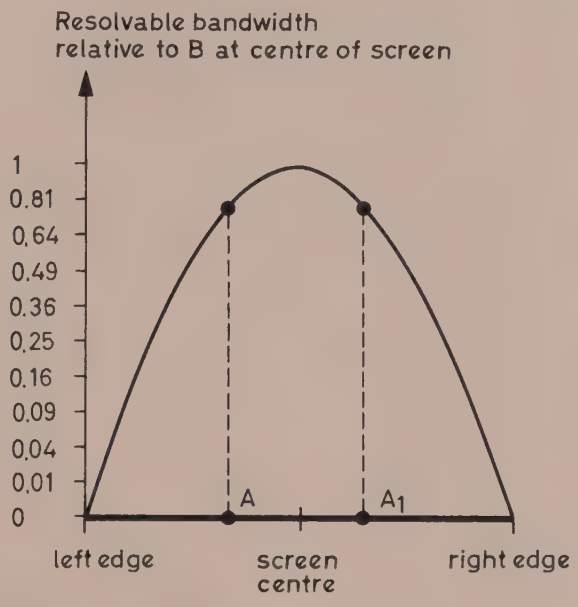

Fig. 25

By varying the centre frequency, the displayed curve can be moved to the left and to the right of the screen. If in doing this a change in resolution is observed, this indication can be used to test the adequacy of the necessary dwell time.

With the aid of the chart in Fig. 26, located above Fig. 27, it is possible to determine a resolution factor for all values of sweep widths and sweep times that are normally encountered. Here, the resolution factor ϱ is defined as the ratio of the smallest bandwidth having a sufficient dwell time as calculated in equation (4) to the entire sweep width, the sweep time being a parameter. This relationship

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may be written as

$$\varrho = \frac{B}{F} \qquad T = \text{parameter}$$

From the chart, we can see that the smaller the sweep width, the larger the resolution factor becomes (constant sweep time). The higher the resolution factor, the worse is the actual resolution since more and more of the displayed sweep is used in the transient response of the test item.

Let us take a special example of an extreme case. Suppose we have a steep-sloped band-pass filter that is to be measured with a sweep width and sweep time such that the filter bandwidth is just equal to the value B, i.e. $\varrho = 100\%$. Instead of seeing a straight line response curve displaced from the 0-reference line, we would see an exponential curve rising to its maximum amplitude to the right of the display screen. The resolution of the actual response curve is therefore extremely poor.

The chart of Fig. 26 may be used to help provide more clarification. Suppose we have a sweep time T of 10 msec and a sweep width F of 100 mc, it is possible to resolve a least bandwidth B of 100 kc or 0.1% of the sweep width. If the sweep width F is decreased to 100 kc with the same sweep time T, a least bandwidth B of 3.16 kc can be resolved or 3% of the sweep width. If the sweep width is decreased even further to 1000 cps, the least bandwidth is only 316 cps or rougnly 30% of the sweep width, i.e. 30% of the sweep width is used in the transient response of the test item. If we wish to resolve or provide sufficient dwell time for 1% of the sweep width, it is necessary to raise the sweep time T from 10^{-2} sec up to 10 sec when using a 1000 cps sweep width.

We should recognize the following points:

Sweep-frequency measuring equipment is especially suited for broadband measurements. The high sweep times (around 10^{-2} sec) give a flicker-free oscilloscope display. When using sweep widths greater than 300 kc, we may obtain in all cases a sufficient dwell time for bandwidths less than 1% of the sweep width, or expressed as 1% resolution.

Since the optical resolution of the displayed patterns on oscilloscopes is limited, a 1% resolution of the sweep width seems to be all that is necessary or reasonable.

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9.3 Detection and Indication of the Measured Values

We have considered up to now the effect of the automatic frequency sweep upon the response curves of test items. The circuits involved in bringing the measured results to the display screen of the picture tube will now be considered. These circuits include the rectifier arrangements for measuring the r-f voltages and the vertical-deflection amplifiers with their display sections. All of the sections must be able to follow the sharpest amplitude variations of the test item without distortion, i.e. the system must have a sufficient rise time. The upper frequency limit f_g to be used in dimensioning the rectifier time constants and the vertical-deflection amplifiers may be calculated from equation (4) for any given sweep width and sweep time.

$$f_g \approx \sqrt{\frac{F}{T}} \qquad (7)$$

We should note that the time constants of the rectifiers and the bandwidths of the deflection amplifiers have to be dimensioned with a limit frequency f_g that is equal to the least resolvable bandwidth for the highest sweep width that is to be used.

Example:

The sweep width F is 10 mc; the sweep time is 10 msec. We are using a linear saw-tooth sweep. The least resolvable bandwidth B is calculated from equation (4)

$$B = \sqrt{\frac{10^7}{10^{-2}}} = 3.16 \cdot 10^4 = 31.6 \text{ (kc)}$$

A resonant circuit with the bandwidth B = 31.6 kc will reach its full response amplitude. In order that the measured response voltage may be displayed without distortion, it is necessary that the diode detector and the vertical-deflection amplifier are able to handle a frequency as high as 31.6 kc.

9.4 Diode Detectors and Vertical-deflection Amplifiers with Inadequate Bandwidths

In the above example in paragraph 9.3, the resolution would be very high using a vertical deflection system capable of handling 31.6 kc since the resolution factor is 0.316%. The oscilloscope display can only be optically evaluated to about 1% of its displayed width (sweep width) so that a resolution factor of 0.316% is not necessary. Logi-

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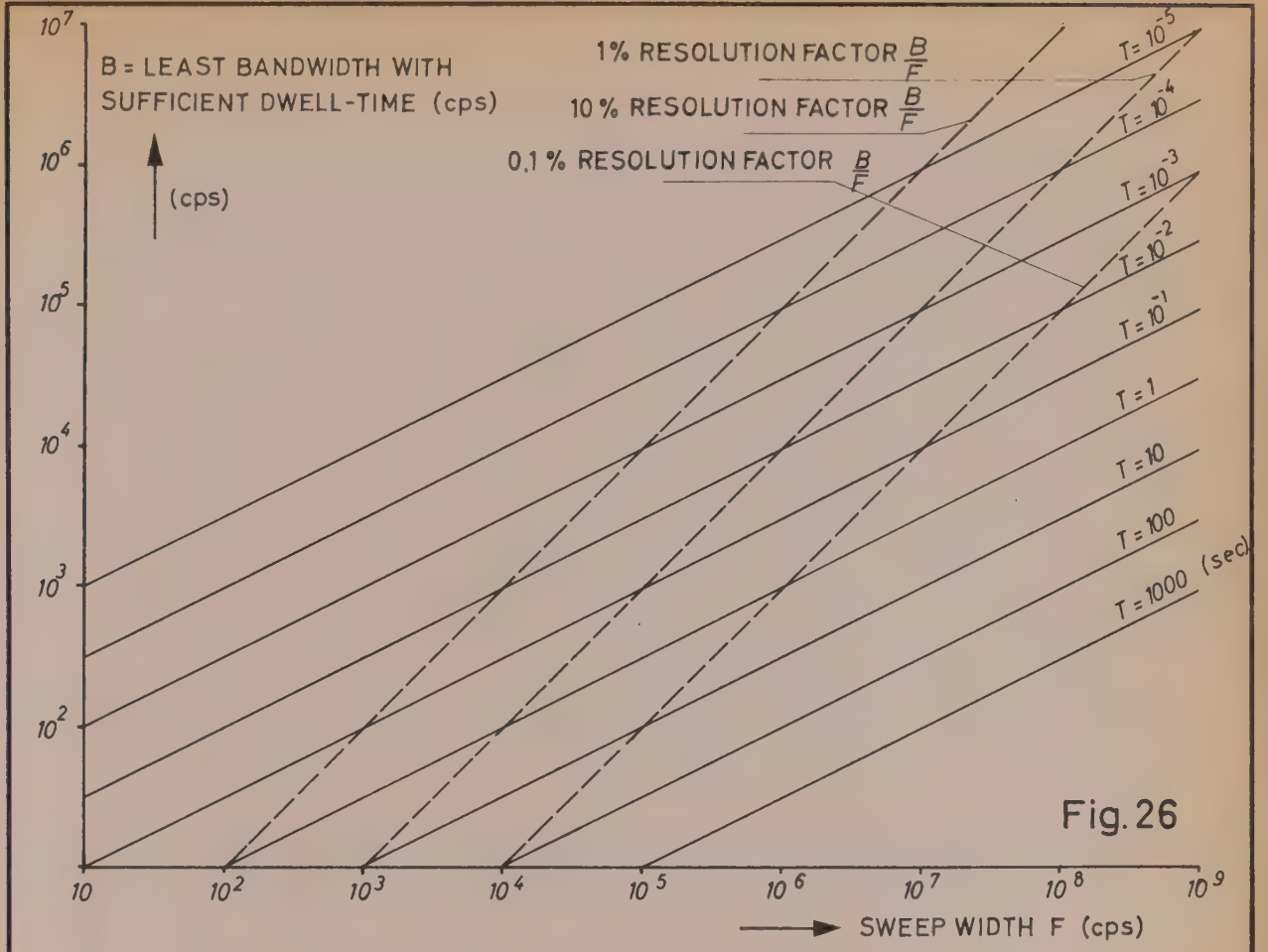

Fig. 26

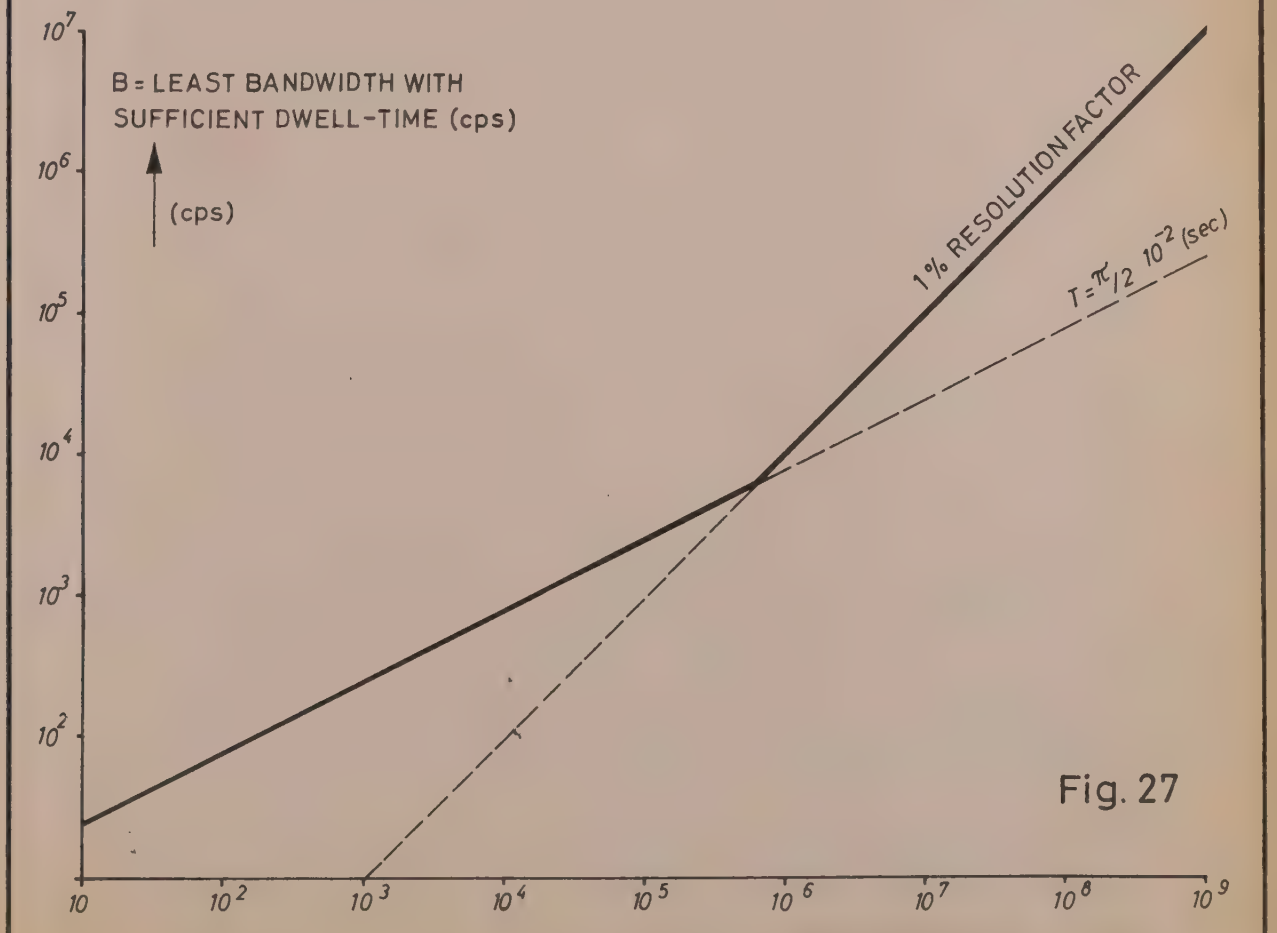

Fig. 27

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cally, it is not necessary to build a deflection system with such a short rise time corresponding to a bandwidth of 31.6 kc. The deflection system in the POLYSKOP has a rise time of about 0.1 msec which corresponds to a bandwidth of about 7 kc. This results in a resolution factor of 1% for a sweep time of 10 msec. This resolution factor, governed only by the deflection system, remains constant at 1% for sweep widths over 300 kc. Under 300 kc, the resolution factors vary according to the relationship expressed by equation (4). Sweep widths under 300 kc cannot be adjusted on the POLYSKOP, so that for all practical purposes the POLYSKOP has a constant resolution factor of 1%. Fig. 27 shows the bandwidth B as a function of sweep width. Below the bend, the slope of the curve is determined by the sweep time of a 50-cps sine wave. Above the bend, the slope is determined by the rise time of the deflection system which gives a constant 1% resolution factor.

9.5 Effect of an Excessive Sweep Rate upon the Measurements

If a resonant circuit with the bandwidth B is swept with a frequency at such a rate that the dwell time is shorter than its transient response time, two very important effects may be determined (references 1) in addition to the insufficient amplitude response.

(1) The amplitude maximum occurs at a frequency different from that determined from a point by point measurement. The maximum amplitude frequency obtained from the sweep method lies higher than it should be, if the sweep is made in the low-to-high frequency direction. The reverse is true for a high-to-low sweep. If both the forward and reverse sweep response curves are simultaneously displayed, two resonance curves appear beside one another (Fig. 28).

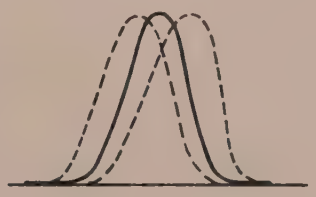

Fig. 28

(2) The bandwidth of the test item is measured larger than it actually is.

These two effects make themselves evident, even if the dwell time is sufficient for the test item, when the rise time of the deflection system is not adequate to give a faithful reproduction of the response curve.

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When measurements are made on steep-sloped bandpass filters, the rise and fall of the response curves are displaced in frequency and appear flatter than they actually are (Fig. 29).

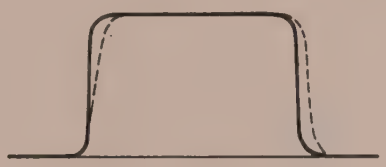

Fig. 29

9.6 Effect of Distortion in the Measuring Signal upon the Measurements

Signal generators used for frequency sweeping have distortion factors in the neighbourhood of a few per cent just like any other good signal generator of the usual construction. We want to investigate the effect of distortion upon the measuring accuracy.

In general the emf of the signal generator is held constant with an automatic control circuit that is actuated from the peak value of the r-f output voltage. If the r-f output has harmonic distortion, the r-f peak values vary from the actual value of the fundamental frequency. For the most part, one may assume that the harmonic frequency components do not have sudden changes, but remain rather constant. As long as the bandwidth of the test item is relatively small, no noticeable measuring error will be caused by distortion in the measuring signal.

The situation is different when making measurements over very wide frequency ranges, especially in the video frequency range. Here the distortion of the measuring signal may lead to a display error that is up to twice as high as the signal generator distortion itself.

The easiest example for explanation is that of a low-pass filter. Suppose the filter has an upper limit frequency of 10 mc. It is therefore not possible for harmonic frequencies over 5 mc to pass through to the output. A step in the response curve is noticeable at 1/2 the limit frequency caused by the elimination of the second harmonic from the output. This step does not actually exist in the response curve of the test item. Another step is noticeable at 1/3 the limit frequency due to the elimination of the third harmonic (Fig. 30).

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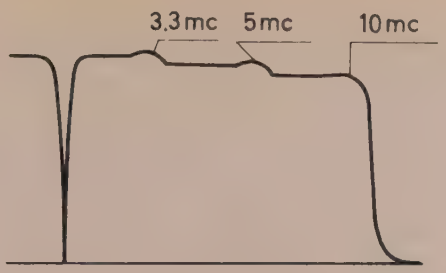

Fig. 30

Distortion caused by the test item itself (overdriving or non-linear characteristics) shows up in the measured results in the same manner.

We should note that distortion in the measuring signal or distortion caused by the test item shows up in the measured response curve as a measuring error, especially in wide-band measurements.

When making measurements on tuned trap circuits, the fundamental signal is suppressed, but not its harmonics. It must always be kept in mind that the distortion in the measuring signal causes a definite minimum indication no matter how high the actual signal suppression is (Fig. 31).

Fig. 31

Such measuring errors can only be avoided when the voltage at the output of the test item is measured with a selective circuit so that the harmonics are not included in the measurements.

9.7 Behaviour of Diodes Measuring Signals containing Distortion

If an r-f voltage of a few volts is applied to a diode rectifier arrangement, the rectification is linear and follows the peak value of the r-f voltage. This is not the case with small r-f voltages of a few millivolts. The diodes are therefore driven on the curved portion of their characteristic curves; the rectification efficiency is lessened and the output voltage is no longer proportional to the peak values, but rather the effective values of the r-f voltage. The sweep signal generator output voltage is controlled from a diode

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circuit operating at a sufficient voltage level to provide a linear peak rectification. Because of the pass-band attenuation and the attenuation in the test item, the diode probe rectifier connected in the test object output may be driven by a very low voltage where linear detection does not prevail. The difference in operating levels of the detector diodes causes measuring errors, especially when making measurements on low-pass filters using a measuring signal that contains distortion.

When measuring a low-pass filter with a measuring signal containing distortion, the rectifier arrangements give different measuring results when the filter is driven with various input levels. This is especially true for test items having high pass-band attenuations.

10. Photographing the Display on the POLYSKOP

If it is desired to photograph the test patterns on the picture screen, any good camera is suitable. A photograph can be made without the use of a tripod by using the following:

Film sensitivity . . . 23° DIN or ASA 200
Exposure time . . . . 1/25 sec
Lense opening f/3.5

Single lense reflex cameras are especially suited for this purpose because they are free from parallax errors.

When setting up the POLYSKOP, one should take care that no direct reflections from the room lighting are to be seen in the picture screen. It is better to darken the room, but it is not absolutely necessary. The person operating the camera should not wear white clothing such as a laboratory smock since the image of the person will also be included in the photograph.

The brightness control of the POLYSKOP should only be advanced so far that a sharp display pattern still exists. Using full beam intensity at the expense of sharpness, the exposure time may be reduced to 1/50 sec.

If the display patterns are to be photographed often, we recommend that a lense attachment be procured that allows the full screen to be photographed from a distance of about 60 cm.

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